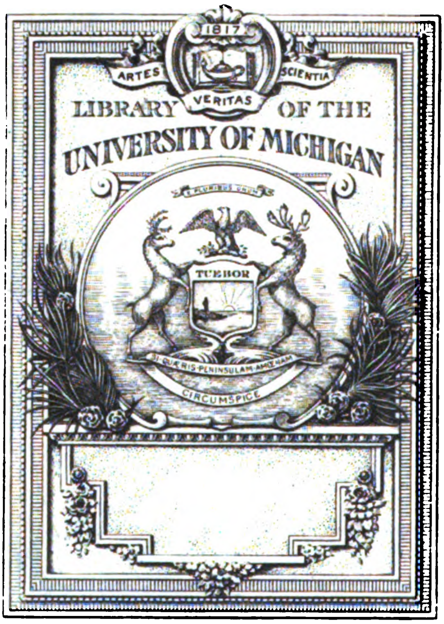
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Twenty-Eighth Annual Report

of the

New Jersey State

Agricultural Experiment Station

and the

Twentieth Annual Report

of the

New Jersey Agricultural College Experiment Station

For the Year Ending October 31st

1907

TRENTON, N. J.
MacCrellish & Quigley, State Printers, Opposite Post Office.
1908.

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New Jersey Agricultural Experiment Stations

NEW BRUNSWICK, N. J.

1. STATE STATION. ESTABLISHED 1880.

BOARD OF MANAGERS.

HIS EXCELLENCY EDWARD C. STOKES, LL.D., ... Trenton.
Governor of the State of New Jersey.

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President of the State Agricultural College.

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Professor of Agriculture of the State Agricultural College.

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(Vacancy.)

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EDWARD B. VOORHEES, Sc.D., ... Director.
IRVING S. UPSON, A.M., ... Chief Clerk, Secretary and Treasurer.
MARY A. WHITAKER, ... Stenographer and Typewriter.
IRVING E. QUACKENBOSS, ... Assistant Clerk.

CHARLES S. CATHCART, M.Sc., Chemist.
JAMES W. KELLOGG, B.Sc., Assistant Chemist.
VINCENT J. CARBERRY, Assistant Chemist.
GEORGE H. BURTON, Laboratory Assistant.
LESTER H. WILLIAMSON, Sampler and Assistant.
HARRY W. WILLIAMS, Janitor.

JOHN B. SMITH, Sc.D., Entomologist.
GEORGE A. BILLINGS, B.Sc., Dairy Husbandman.
MAURICE A. BLAKE, B.Sc., Horticulturist.
FREDERICK C. MINKLER, B.S.A., Animal Husbandman.
GEORGE G. MANNING, Field and Greenhouse Assistant.
CLARA M. CHANDLER, Stenographer and Assistant.

2. AGRICULTURAL COLLEGE STATION. ESTABLISHED 1888.

BOARD OF CONTROL.

The Board of Trustees of Rutgers College in New Jersey.

EXECUTIVE COMMITTEE OF THE BOARD.

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STAFF.

EDWARD B. VOORHEES, Sc.D., ... Director.
IRVING S. UPSON, A.M., ... Chief Clerk.
IRVING E. QUACKENBOSS, ... Assistant Clerk.

JULIUS NELSON, PH.D., Biologist.
BYRON D. HALSTED, Sc.D., Botanist and Horticulturist.
EARLE J. OWEN, B.Sc., Assistant in Horticulture.
NAHUM D. SHORE, B.Sc., Assistant in Plant Breeding.
ELIZABETH R. NICHOLAS, Stenographer and Typewriter.
JOHN B. SMITH, Sc.D., Entomologist.
AUGUSTA E. MESKE, Stenographer and Typewriter.
JACOB G. LIPMAN, PH.D., Soil Chemist and Bacteriologist.
PERCY E. BROWN, B.Sc., Assistant Chemist.

To His Excellency Edward C. Stokes, Governor of the State of New Jersey:

SIR—I have the honor to submit herewith the Twenty-eighth Annual Report of the New Jersey State Agricultural Experiment Station, as required by the law establishing the Station, which was approved March 10th, 1880, and which is chapter 106 of the laws of that year.

DAVID D. DENISE,
President.

NEW BRUNSWICK, N. J., November 30th, 1907.

To His Excellency Edward C. Stokes, Governor of the State of New Jersey:

SIR—In compliance with an act of Congress, approved March 2d, 1887, and with an act of the Legislature of this State, approved March 5th, 1888, I beg leave to submit, on behalf of the Trustees of Rutgers College in New Jersey, maintaining Rutgers Scientific School, the New Jersey State College, for the benefit of Agriculture and Mechanic Arts, the Twentieth Annual Report of the operations of that department of the College which has been organized in accordance with said act of Congress, and is known as "The State Agricultural College Experiment Station."

W. H. S. DEMAREST,
President.

NEW BRUNSWICK, N. J., November 30th, 1907.

TREASURER'S REPORT.

IRVING S. UPSON, in account with the NEW JERSEY STATE AGRICULTURAL EXPERIMENT STATION, November 1st, 1906, to October 31st, 1907.

Appropriation for Salaries and Expenses.

RECEIPTS.

From State Treasurer,	$20,000 00

PAYMENTS.

Salaries and Pay of Chemists and Assistants,	$12,343 41
Expenses of Board of Managers,	33 94
Printing,	223 99
Postage, Telephone and Telegraph Service,	216 26
Furniture,	222 25
Fuel,	545 66
Gas, Electricity and Water,	316 69
Laboratory Expenses,	583 23
Field and Feeding Experiment Expenses,	2,938 48
Freight, Express and Cartage,	142 88
Expenses Collecting Samples of Fertilizers,	317 20
Traveling Expenses,	255 16
General Fittings, Repairs and Improvements,	933 51
Insurance,	855 09
Reference Books,	57 25
Contingent Expenses,	15 00
Total,	$20,000 00

Appropriation for Carrying out the Provisions of "An Act Concerning the Regulation of the Sale of Concentrated Commercial Feeding Stuffs."

RECEIPTS.

From State Treasurer,	$3,000 00

PAYMENTS.

Salaries and Pay of Chemists and Assistants,	2,271 88
Laboratory Fittings, Apparatus and Supplies,	198 34
Expenses Collecting Samples of Feeding Stuffs,	191 84
Printing Bulletin,	337 94
Total,	$3,000 00

Appropriation for Printing Bulletins.

RECEIPTS.

From State Treasurer,	$1,500 00

PAYMENTS.

For Printing Bulletins,	$1,500 00

Appropriation for Carrying out the Provisions of "An Act to Regulate the Sale of Paris Green."

RECEIPTS.

From State Treasurer,	$500 00

PAYMENTS.

Salaries and Pay of Chemists and Assistants,	$399 99
Printing Bulletin,	100 01
Total,	$500 00

Appropriation for the Purpose of Carrying into Effect "An Act to Provide for Locating and Abolishing Mosquito-breeding Salt-marsh Areas within the State, for Assistance in Dealing with Certain Inland Breeding Places, and Appropriating Money to Carry its Provisions into Effect."

RECEIPTS.

From State Treasurer,	$4,325 52

PAYMENTS.

Salaries and Compensation of Assistants,	$3,249 99
Laboratory and Field Apparatus and Supplies,	258 78
Freight and Express,	3 46
Traveling Expenses,	721 67
Printing,	91 62
Total,	$4,325 52

The Auditing Committee of the Experiment Station has examined the accounts of the Treasurer of said Station, and has found them correct.

JOHN E. DARNELL.
GEORGE E. DECAMP.
Auditing Committee.

FINANCIAL STATEMENT.

The Trustees of Rutgers College
for
The New Jersey State Agricultural College Experiment Station
in account with
The United States Appropriation, 1906-1907.

RECEIPTS.

From the Treasurer of the United States—	
Hatch Act,	$15,000 00
Adams Act,	7,000 00
	$22,000 00

DISBURSEMENTS.

	Hatch Act.	Adams Act.	
Salaries,	$8,250 00	$5,410 00	$13,660 00
Labor,	838 07	302 03	1,140 10
Publications,	1,040 89	....	1,040 89
Postage and Stationery,	1,101 54	....	1,101 54
Freight and Express,	176 07	....	176 07
Heat, Light, Water and Power,	419 99	....	419 99
Chemical Supplies,	255 70	....	255 70
Seeds, Plants and Sundry Supplies,	247 20	63 62	310 82
Fertilizers,	246 40	....	246 40
Feeding Stuffs,	232 20	....	232 20
Library,	579 97	308 83	888 80
Tools, Implements and Machinery,	....	116 94	116 94
Furniture and Fixtures,	246 39	....	246 39
Scientific Apparatus,	273 59	798 58	1,072 17
Live Stock,	....	....	....
Traveling Expenses,	335 55	....	335 55
Contingent Expenses,	15 00	....	15 00
Buildings and Repairs,	741 44	....	741 44
	$15,000 00	$7,000 00	$22,000 00

We, the undersigned, duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the New Jersey State Agricultural College Experiment Station for the fiscal year ending June 30th,

1907, that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $22,000, and the corresponding disbursements $22,000, for all of which proper vouchers are on file, and have been by us examined and found correct, thus leaving no unexpended balance.

And we further certify that the expenditures have been solely for the purpose set forth in the acts of Congress, approved March 2d, 1887, and March 16th, 1906.

(Signed) W. H. S. DEMAREST,
EDWARD B. VOORHEES,
Auditors.

REPORT OF THE DIRECTOR.

Report of the Director.

The annual report for 1907 shows the results of the work and investigations of the year in the various departments of the Stations, with the exception of such work as has appeared in bulletin form. These reports and bulletins show that the work of the various departments is increasing in volume and value from year to year, due to the increased facilities now provided. The main additions to equipment the past year have been fifteen acres of land for experiments in forestry, upon which, during the past year, 25,000 trees and seedlings have been planted, representing seven varieties of hard woods, and four varieties of conifers; ten acres of land for field experiments in the Department of Soil Bacteriology; five acres in the Department of Botany and Plant Breeding, and three acres for experiments with fertilizers and rotations, together with areas sufficient to increase the number of cylinders in the investigations of the chemistry and bacteriology of soils from 120 to 440. A brief summary of the work is herewith presented.

1. Examination of Fertilizers.

In the prosecution of the fertilizer control 981 samples were received, representing:

438 brands of complete fertilizer.
26 special compounds.
9 home mixtures.
34 ground bones.
104 fertilizer materials.
37 sundry materials.
17 duplicate samples of complete fertilizers.

The analysis of these samples required about 5,800 separate determinations. The results of the analysis of mixed fertilizers

still show a great deficiency in the element nitrogen. This is presumably due to the increased cost of this constituent, which undoubtedly caused the manufacturers to figure much more closely on this element than in the past. Hence, when the mixing is not thoroughly made deficiencies are more likely to occur in this element than in the case of phosphoric acid and potash. When guarantees are not reached, preliminary reports of analysis are forwarded to manufacturers, in order that they may be advised as to the deficiencies previous to the publications of the bulletin. Where wide deficiencies occur, duplicate samples are always taken, provided such duplicates are in the laboratory, in order to guard against publishing the analysis of a brand which manifestly does not represent the claimed composition of the goods. It has been found, however, that in most cases where deficiencies occur, it is not a sample deficiency, but either due to imperfect mixing or to an insufficient control of the composition of the raw materials entering into the mixture. Many small manufacturers, especially, assume an analysis of raw materials, which is not a correct one, and thus make it impossible for the guarantees to be reached. This view is the most favorable one that can be adopted, in reference to such deficiencies, and it is to be deplored that greater care is not exercised in the preparation of brands, for while in most instances the commercial value of the brand is equivalent to that called for by the guarantee, the formulas are very materially changed.

As in the past, the analysis of home mixtures, specially prepared mixtures, fertilizer materials and ground bones, show very clearly the advantage to the farmer of purchasing supplies from original sources, both in the matter of obtaining superior forms and in reducing the cost per pound of the constituent elements.

A careful study of the results obtained by farmers from this method of purchasing fertilizers indicates that the results are quite as satisfactory from the standpoint of return per unit of supply, besides a very considerable saving in the cost of materials. These advantages, however, are as a rule proportionate to the amounts purchased. That is, a farmer using but one ton or a few tons would not receive the same financial advantage as those

purchasing carloads or more, though in all cases it is very important that the farmer should study the relation of guarantee and selling price, both in the fertilizer materials and in the mixed goods.

The results of the analyses, also, show what has been so frequently pointed out heretofore, that on the whole high-grade goods or brands carrying, say 4% ammonia, 8 "available" phosphoric acid and 8 of potash, supply the constituents more cheaply than those carrying 2% ammonia, 8 "available" phosphoric acid and 2 of potash. The necessity for the purchase of low-grade goods is not apparent, when it is remembered that it is not so much a question of proportion of elements as it is of quantity and that a smaller quantity of a high-grade fertilizer would be likely to give quite as good returns as a larger quantity of a low-grade fertilizer, carrying practically the same amounts of fertility elements. There is no real advantage to be derived from the purchase of low-grade fertilizers.

Commercial Feeds.

Five hundred and twenty-eight samples were collected, of which 348 required guarantees and 180 did not. Of these, 471 were selected for analysis, 304 of which belonged to the class that required a guarantee; 227 of the 304 samples, or 75 per cent., fulfilled their guarantees, which is a marked improvement over the last three years, and by far the best showing of any of the Station's inspections. Deficiencies, as a rule, were found rather in the protein than in the fat, though 21 samples were deficient in both protein and fat.

Of the 167 samples, which did not require a guarantee, all were pure products. The wheat bran and feeding flours, however, were this year below their claimed quality. No direct adulterations were shown, though many samples of inferior quality were found.

Owing to the gradually increasing cost of feeds, there is found a greater tendency each year to load the markets with mixed feeds, the object of which in many cases is to dispose of refuse

products, like oat hulls and materials of a similar character that could not be sold for feed, if offered in their original form. There is no question as to the value of many of the materials which are added to the hulls, but it seems an unwise expenditure of money for farmers and others to purchase in mixed feeds materials which they would not buy if they knew their character and composition, and which in many instances possess a lower feeding value than home-grown refuse products as corn stalks and straws of the cereals, now being wasted in large measure upon the farm.

It is also shown that while mixed feeds of this character have a genuine feeding value, the cost of nutrients of the lower quality is in many cases greater than the cost of nutrients in products of standard quality. Farmers are protected in a marked degree by a statement as to the composition of their feeds, still a guarantee of protein and fat in a feed is not a sufficient guide as to the value any more than it is a sufficient guide in a fertilizer to state the total percentages of nitrogen, phosphoric acid and potash. Quality of nutrients is quite as important as quality in the fertilizer constituents.

Cottonseed and linseed meals, distillers' grains, brewery products, gluten feeds, wheat bran and middlings, buckwheat middlings, etc., are standard products, and one or more of these are the feed products that are added to the various refuse materials to make them palatable and nutritious. There is no good reason why the farmer should not confine himself to the purchase of these feeds, mixing them with his cut straw and corn stalks, if he desires to dilute them to the same degree as are the bulk of the mixed feeds.

Miscellaneous Samples.

In addition to the samples mentioned, 37 samples, representing sundry materials, were analyzed either in connection with investigations being carried on in other departments, or for the purpose of determining the value of such products as feeds, fertilizers or soil amendments.

Paris Green.

Twenty-nine samples of Paris green were received; 20, or 69%, of which represented that purchased in bulk, and the remaining 9 samples were in original packages. With one exception, all the samples were guaranteed, and the analysis showed that all were of good quality, including the one not guaranteed. But one sample did not reach the 50% limit of arsenious oxid combined with copper, as required by law.

Changes in Staff.

Owing to the resignation of Mr. John P. Street, chief chemist, to accept a similar position at the Connecticut Experiment Station, the chemical investigations to which he had given much of his time during the past few years, and especially the study of the carbohydrate group of nutrients in feeds, has been temporarily suspended. This work will, however, be continued as time permits.

Mr. James W. Kellogg, who was engaged to take the place of Mr. Wm. P. Allen, assistant chemist, resigned October 1st, to accept a responsible position with the Pennsylvania Department of Agriculture.

Notwithstanding these changes, Mr. Chas. S. Cathcart, a graduate of the College, who assumed the position of chief chemist May 1st, has been able to complete the analytical work in the Chemical Department at the usual time.

Bulletins Nos. 201, 205 and 206, containing the results of the feed, Paris green and fertilizer inspections during the past year, have been issued by this department.

DAIRY HUSBANDRY.

The work in this department has been carried out along the lines followed in the past few years, though considerably enlarged in its scope. The lines of work are:

1. Feeding Experiments.

In this department, an experiment was conducted to determine the position of corn distillers' grains, a product rich in protein, and a comparatively new feed among such standard feeds as gluten feed, oil meal and wheat bran. The results of this experiment were published in Bulletin No. 204, and show the feed to be very palatable, and on the basis of protein even more economical than the standard feeds supplying the same amount of protein.

An experiment comparing the soiling crops, branyard millet, buckwheat, and corn fodder, with silage and oat and pea hay, showed that the soiling ration produced quite as large a yield of milk and at a saving in cost of both milk and butter. The main point, however, as a result of this experiment is that corn silage can be safely and economically used for summer feeding, a fact which should result in very largely increasing the number of animals that can be kept on a definite area.

2. Soiling Crop Experiments.

The soiling crop experiments this year included rye, wheat, crimson clover, oats and peas, millet, cow peas, Kaffir corn and cow peas, milo maize and cow peas, corn, buckwheat and alfalfa.

Variety experiments were also conducted with cow peas, millet and with combination forage crops.

The result of these experiments show that all may be grown successfully for this purpose, and that they may be so seeded as to furnish a continuous supply of green crops during the summer season, and also that in most cases should the green forage not be needed it can be made into hay that is palatable and useful for winter feeding.

Experiments with field crops included a further test of alfalfa upon two acres, which the first year (after seeding in August) made four cuts, and gave a total yield of 6½ tons of dried hay per acre. An experiment to determine the influence of methods of culture, disking and reseeding in September, showed that this method could be carried out with success, resulting in an increase in the yield and value of the crop.

Experiments with fall seeding of timothy and clover, without cover crop, were very satisfactory; yields of 4 tons per acre having been obtained in June, after seeding the preceding August.

Fertilizer experiments were also conducted upon corn, comparing various phosphates and continuous fertilizing, without cover-cropping.

Further experiments are also in progress to study the advantages of cover crops, both cereals and legumes, and the possible improvement of regular farm rotations.

3. Experiments with the Dairy Herd.

These experiments included the making of records of all of the factors involved in milk production, and shows in detail the cost of producing milk under sanitary conditions. These records are very apropos at the present time, owing to the controversy in reference to the cost of milk when made under the requirements now demanded by various municipalities.

HORTICULTURE.

In this department, the work of the experiment grounds and in the plant-houses has been continued along the usual lines, namely, a comparison of various varieties of apples, pears, plums and cherries, as well as a study of their fertilizer needs and the results of irrigation.

Mr. Maurice A. Blake was engaged as horticulturist to fill the position left vacant by Dr. George F. Warren, and began his duties here December 1st, 1906.

In addition to carrying on the regular work, as here outlined, new experiments were started as follows:

A variety test of strawberries; a comparative study of the effect of muriate and sulphate as sources of potash for strawberries; the setting of an orchard of dwarf apples, for the purpose of securing more immediate results in the use of the different kinds of fertilizers, mainly of muriate and sulphate of potash; the results of cover-cropping, with both leguminous and non-

leguminous crops. Studies are also being made as to the value of the sand cherry as a stock for peaches in order to control the borer, and also to compare the various grades of peach stock offered by nurserymen, to determine the differences in growth, and the relative value of different types of trees.

An experiment was also carried out to study the method of controlling mushroom maggots.

In the experimental peach orchard, established in Hunterdon county last year, the work has been continued, and another of a similar character begun at Vineland, N. J. The object of these experiments being to study in detail all the problems in connection with peach growing, in the two peach-growing sections of the State.

The horticulturists has also spent a great deal of time in visiting orchards throughout the State, studying the conditions and methods of orchardists.

Miss Jennie A. Voorhees, assistant horticulturist, resigned on June 1st.

Soil Chemistry and Bacteriology.

The additional funds provided for the work of this department within the past year have allowed an increase both in the laboratory and field equipment. The new laboratory equipment includes an addition to the incubator room, a Geryk air-pump, intended for certain investigations on the physiology of soil bacteria; new microscopes; a hot-air sterilizer, and an analytical balance.

The additions to the field equipment include, first, a plant of 320 cylinders, which is being devoted to a rotation experiment, wherein 8 distinct soil types, most of them taken from the trucking districts in south and middle Jersey, are to be studied from the standpont of nitrogen gain and utilization. The four main crops in the rotation are rye, corn, potatoes and oats. This rotation allows the introduction of at least three legumes, and in addition one non-legume, as catch crops. The value and cost of the nitrogen and organic matter obtained in the catch crops are to be compared with that of the nitrogen and organic matter

in horse manure, a comparison of considerable practical significance, since the horse manure purchased in very large quantities by the farmers of New Jersey is not the most economical source of these constituents. The modifications produced in the cylinder soils by the different methods of treatment are to be further studied both chemically and bacteriologically, particularly with the view of ascertaining the influence of the amount and composition of the soil humus on the bacterial flora of the soil.

Second, 100 metal boxes for the study of liming and various methods of fertilizer treatment, as affecting certain groups of soil bacteria. One of the experiments completed in the past year yielded some interesting results. Magnesian and non-magnesian lime proved of unequal value in their relation to the yields of oats and of clover on the one hand, and to the activities of ammonifying, nitrifying and nitrogen-fixing bacteria in the soil, on the other. These experiments also showed that the accumulation of nitrates in uncropped soils has a limit even where losses from leaching are excluded. It would seem that when large quantities of nitrates are present in uncropped soils, conditions are created for their disappearance either through denitrification or through their transformation into organic nitrogen compounds. The box experiments show, further, that the ammonifying coefficient of soils is enhanced to a very marked extent by liming, the magnesian lime frequently proving superior in this respect than the non-magnesian lime.

Aside from the cylinders containing each 150 to 190 pounds of soil, and the metal boxes containing in each case 45 pounds of soil, a series of experiments is also being carried on in glass pots containing in each case about 20 pounds of soil. Eighty such pots are employed for the study of the fertilizer requirements of five types of soil; while forty-two additional pots are used in a comparative study of the availability of various nitrogenous substances, particularly calcium cyanamide, calcium nitrate and cyanate. Experiments were likewise continued in the past year with 140-pound quantities of light soil, that have been under observation for a number of seasons. The gains of nitrogen revealed in these soils, notwithstanding the exclusion of leguminous vegetation, leads to the belief that under certain

conditions Azotobacter and other non-symbiotic nitrogen-gathering bacteria may play a rôle of considerable importance in supplying higher plants with combined nitrogen.

The older cylinder experiments comprising a plant of 120 cylinders, are devoted in part to a continuation of the investigations initiated in 1898, and in part to inoculation studies with Azotobacter. The past season completed the second 5-year rotation in the "Investigations Relative to the Use of Nitrogenous Materials." The great mass of analytical data accumulated in the 10 years represent some extremely valuable experimental evidence on denitrification problems, and more generally, on the availability of various inorganic and organic nitrogenous substances, either when used alone, or in combination with one another. Furthermore, new light is thrown by these experiments on the losses and gains of nitrogen in the soil under the several methods of nitrogen treatment, as well as on the losses of calcium and magnesium carbonates, and the gradual change in the reaction of the soil. It is expected that these data, together with a critical discussion of the literature pertaining thereto, will be ready for publication in the near future.

The laboratory experiments proper, carried out within the past year, concern largely the examination of various methods of possible utility in the determination of the part played by definite groups of soil bacteria in the production of available plant-food. We are still far from a clear understanding of the qualitative and quantitative bacterial changes which the protein compounds in the soil-humus must undergo in order that they may supply the legitimate needs of the crop. The physiological efficiency of individual species undoubtedly plays here a prominent rôle, and the laboratory experiments are partly devoted, therefore, to the isolation of the better-known species of decay bacteria from different soils, and the determination of the amount of chemical change produced by them under identical culture conditions. A considerable amount of work has also been carried out in the laboratory in the study of methods for the determination of calcium and magnesium carbonate in the soil. The importance of these and other basic compounds in the soil to the bacteria in the latter is so far-reaching that their

accurate estimation is essential in the measuring of the bacterial factor in soil fertility.

The present report contains inoculation studies with Azotobacter in cylinder soils; bacteriological studies of a Madison soil; and ammonification studies on box soils, which has been subjected to various methods of treatment. The technical publications of the department within the past year, includes a paper in the Journal of the American Chemical Society on "The Losses of Ammonia from Culture Solutions," and a bulletin of the Office of Experiment Stations, entitled "A Review of Investigations in Soil Bacteriology."

BIOLOGY.

In the biological department, the application of von Behring's method of rendering cattle immune to tuberculosis, has been continued to a limited extent. It is yet too early, from our own data, to make a definite statement as to the real value of this method, which promises so much more than any remedy hitherto offered.

The main work of the biologist has been the continuation of the "Scientific Researches in Oyster Culture." The State law, providing for the expenses of these studies, was revised at the legislative session of 1907, so as to change the amount that may be appropriated annually from two hundred to twelve hundred dollars. This latter amount was placed in the appropriation bill, and the greater part of it has been used in providing much needed equipment. A twin-screw sail bateau, with naphtha engines, has been built expressly to enable the investigator to reach all parts of the field of operations. It is hoped that this appropriation will be duplicated next year, so that a suitable laboratory boat may be provided.

The researches in oyster culture during the summer of 1907 were confined principally to the Barnegat region, and limited to the study of the fixation of the oyster fry to shells. This is the vital point in seed production on which the whole oyster industry rests.

Very encouraging progress was made. The period elapsing between spawning and spatting was found to be longer than was anticipated. It was also found possible to follow the development of the fry throughout the period, and to study its attachment. It thus becomes feasible to predict with great accuracy, the proper data at which shells should be planted to secure the best results. Scarcely any shells placed by the planters last season were put down at the proper time. The "set" secured was far inferior to that attaching to the shells of the experiments.

Such results warrant attempts at commercial applications, such as the trial of co-operative experiments in seed production, accompanied by public instruction in the character of experimental results.

BOTANY.

As for the past few years, the work in the botanical department has been along the general lines of the improvement of truck crops, including in particular sweet corn, tomatoes, eggplants, snap and lima beans, summer and winter squashes, peas, okra, onions and salsify.

The unusually unfavorable season has retarded the progress of work with sweet corn. A cross of the Golden Bantam-Premier has proved productive. The stalks often bearing three marketable ears. The Golden Bantam-Stowell cross shows qualities that may make it a desirable addition to the list of medium-season, long-grained kinds. The subject of flintiness is being studied in connection with the crosses effected with flint and dent corns.

Progress has been recorded for the year in the attempt to lengthen the axis of large tomatoes and, shortly, it is hoped to have some varieties of the "goose-egg" type that will be new to the trade. In connection with the above work, some combinations have been made that result in plants and fruits that merit a trial by the truckers of the State.

Among eggplants, the Ivory has been so far developed as to be ready for a test distribution; it having superior external

form, combined with a white surface and flesh. The Jersey Pink is another sort that has merit, seeds of which are ready for distribution. The hybrids between the American and Chinese species have been grown for another year, and many additional facts determined. The hope of securing prolific plants bearing fruit of marketable size, and sufficiently firm in flesh to bear long shipment, is being realized. The occurrence here of smooth plants may provide a means of developing a variety that will be free from spines and thus add greatly to the comfort of handling eggplants.

A large amount of time and ground space have been given to the development of improved snap beans and one creation in this line is ready for distribution, while others are well under way. Many crosses among the lima beans are made and being developed. Hybrids between the Scarlet Runner and snap beans show much of promise and, shortly, some strains will be ready for a wide trial.

The soil and the season were both quite unfavorable to the growth of squashes and the expected progress was not made, but among the summer sorts some crosses of merit were carried forward a year and a few seeds secured for distribution.

With peas, substantial steps were taken with the spring crop, and enough crosses are in hand for a large planting next year.

In connection with the above and other lines of breeding, the subject of correlations is now taken in hand seriously, and the relation between seed and seedling, seedling and plant, plant and fruit, are some of the problems under investigation. For example, the inverse correlation between thickness of flesh of squashes, and number and viability of seeds, is being determined by a hyrometric method.

For the greenhouse, a study of the unit characters in garden peppers is begun, involving all of the available types of the subject.

During the year, two bulletins have been issued, No. 199, "Station Novelities in Truck Crops," and No. 202, "The Forest Trees of New Jersey." The seed distribution last spring embraced 1087 packets as follows: Corn, 411; tomatoes, 33; eggplants, 121;

winter squashes, 128; Pak-Choi, 47, and Pe-Tsai, 50 packets, respectively.

ENTOMOLOGY.

In the department of insects the work on the root maggots begun during the season of 1906 was continued, and the recommendations made in Bulletin No. 200 and in the report of 1906, were tried out, so far as possible in actual field tests in different counties in the State.

Work with insecticides continued to form an important feature, and the effect of carbolic acid, in particular, was tested and observed in actual orchard work. A number of arsenical preparations—arsenate of lime, of barium and of iron—were experimentally used, and arsenate of iron seems likely to prove useful as an effective, safe and inexpensive insecticide.

The use of the soluble or miscible petroleum oils, first recommended by this Station has extended to such a degree that a considerable number of brands are now on the market, and studies have been made which will probably make it possible, in the near future, for the better equipped farmers to produce their own material. On the other hand, so many fruit growers object to the preparation of the lime and sulphur washes, that a commercial article has been in demand. Many of such have been tested by this department, and one of them, the Rex Brand, promises to fill all the requirements of the orchardist at a reasonable cost. Experiments made in three counties show uniformly good results.

Local outbreaks of the army worm have been observed and investigated, and the unusual abundance of the bag worm in some places has made possible some studies on parasitism. The season has demanded attention to many scattered outbreaks rather than detailed studies of any one problem.

Incidental to the mosquito work, observations have been made and data have been gathered as to the general effect of our drainage operations upon the productive qualities of the areas treated and some very satisfactory results have been secured.

Mosquitoes.

In the mosquito work practical operations have been carried on and the following areas have been ditched and drained:

The Jersey City marshes, at a cost of, ...	$2,100
" Elizabeth " " "	5,300
" Linden " " "	3,650
" Raritan " " "	3,475
" Sayreville " " "	525
" Rahway " " "	200
" Woodbridge " " "	2,500
" Carteret " " "	1,400
" Long Beach area south of Beach Haven, at a cost of,......	3,100
" Long Branch marshes, at a cost of, ...	180
" Middletown Township marshes, at a cost of, ...	200
Making a total expenditure of, ...	$22,630

Of this sum, Jersey City, Rahway and Long Branch paid the total cost of the work done within their limits, and the City of Elizabeth contributed $1,000 toward the work done in its territory. Over 1,250,000 feet of ditches have been dug, and approximately 14,471 acres of marsh land have been drained.

Numerous inspections and surveys have been made for local authorities and a very large amount of work has been done as the result of information and encouragement given by this office.

The very curious and complicated life history of *Culex perturbans* has been at last worked out and has developed a species that lives in the soft mud of shallow over-grown swamps under a water covering of from 4 to 8 inches. This knowledge will enable us to control the mosquito pest in some localities which had been helpless heretofore, and covers the last of the New Jersey species whose breeding habits were unknown.

Throughout the year, Mr. H. H. Brehme has served as assistant chiefly in the marsh work, and Mr. J. S. Grossbeck has served as assistant chiefly in laboratory work, and in other field investigations, as well as in preparing maps and other drawings needed.

The various officers of the Stations keep in close touch with state and county organizations, farmers' clubs, and with indi-

vidual farmers through correspondence and visits, and stand ready at all times to give such information and help as their time will permit. This work is a very important part of that performed by the Stations, and is recognized and appreciated by the farmers. It is impossible, however, to make other record of the work in the annual report, though it very largely adds to the duties of the individual officers and the office force.

It is a matter of gratification to be able to report that the value of the investigations of the Stations is not only recognized in our own state and country, but that the work done is highly appreciated and has received the warmest commendation from eminent workers in the same fields in nearly all foreign countries.

All officers and assistants have been efficient and faithful in their work, and have heartily co-operated with the Director in all of his plans for the work of the Station, and he desires to record here his appreciation of their loyal service.

REPORT OF THE CHEMISTS.

Report of the Chemists.

BY CHARLES S. CATHCART.

I. Inspection of Commercial Fertilizers.
II. Inspection of Concentrated Feeding Stuffs.
III. Inspection of Paris Green.

I.

FERTILIZERS.

The inspection during the past year has been thorough; twenty of the twenty-one counties were visited and 891 samples were obtained from 310 different dealers and farmers. Practically all of these samples were taken by the official inspector of the Station; a few, however, were sent in by granges and individuals, and in such cases are considered and marked in the bulletins as unofficial. The samples of complete fertilizers represent the product of 96 manufacturers, if the branches of the American Agricultural Chemical Company are considered separately.

The results of the inspection were published in bulletins 206 and 208, and consisted of the analysis and discussion of the following:

438	samples	of	commercial fertilizers.	
18	"	"	" "	(duplicates).
26	"	"	special compounds.	
9	"	"	home mixtures.	
34	"	"	bones.	
104	"	"	fertilizer materials.	
37	"	"	sundry materials.	
666	total.			

The analysis of the above 666 samples required about five thousand and eight hundred separate determinations.

Manuacturers

WHOSE GOODS HAVE BEEN SAMPLED AND ANALYZED THIS YEAR.

J. H. Allen & Son, ...Lawrence Station, N. J.
American Agricultural Chemical Co., ...2 Rector St., New York City.
Bradley Branch, ...92 State St., Boston, Mass.
Chemical Co. of Canton Branch, ...32 S. Charles St., Baltimore, Md.
Chicopee Branch, ...88 Wall St., New York City.
Clark's Cove Branch, ...81 Fulton St., New York City.
Crocker Branch, ...56 Pearl St., Buffalo, N. Y.
Denise & Denise Branch, ...Freehold, N. J.
East India Branch, ...93 William St., New York City.
Great Eastern Branch, ...Rutland, Vt.
Lambertson & Hance Branch, ...Freehold, N. J.
Lazaretto Branch, ...Baltimore, Md.
Maryland Branch. ....Baltimore, Md.
Milsom Branch, ...963 William St., East Buffalo, N. Y.
Pacific Guano Branch, ...27 William St., New York City.
Packers' Union Branch, ...150 Nassau St., New York City.
Moro Phillips Branch, ...710 Bourse, Philadelphia, Pa.
Preston Branch, ...Greenpoint, L. I., N. Y.
Quinnipiac Branch. ....83 Fulton St., New York City.
Reed Branch, ...16 Exchange Place, New York City.
Sharpless & Carpenter Branch, ...710 Bourse, Philadelphia, Pa.
Susquehanna Branch, ...Baltimore, Md.
Tygert-Allen Branch, ...2 Chestnut St., Philadelphia, Pa.
Wheeler Branch. ....Rutland, Vt.
Williams & Clark Branch, ...27 William St., New York City.
Zell Branch, ...Baltimore, Md.
Armour Fertilizer Works, ...Baltimore, Md.
J. H. Baird. ....Marlboro, N. J.
Baugh & Sons Co., ...20 S. Delaware Ave., Philadelphia, Pa.
The Berg Co., ...Russell and Bath Sts., Philadelphia, Pa.
Bowker Fertilizer Co., ...43 Chatham St., Boston, Mass.
Bradley & Green Fertilizer Co....Ninth St. and Girard Ave., Philadelphia, Pa.
L. E. Brown, ...Red Bank, N. J.
W. M. Brown, ...Cedarville, N. J.
Buffalo Fertilizer Co., ...Buffalo, N. Y.
C. C. Clark & Son, ...Mt. Ephraim, N. J.
The Coe-Mortimor Co., ...24-26 Stone St., New York City.
J. S. Collins & Son, ...Moorestown, N. J.
Collins & Pancoast, ...Merchantville, N. J.
S. V. Davis, ...Shiloh, N. J.
B. F. Demaris & Son, ...Cedarville, N. J.

H. K. Dobbs, ...Mt. Ephraim, N. J.
H. W. Doughten, ...East Moorestown, N. J.
E. Dougherty, ...Philadelphia, Pa.
The Jas. G. Downward Co., ...Coatesville, Pa.
Fritts & Cougle, ...Annandale, N. J.
Glaser Fertilizer Co., ...Plainfield, N. J.
Jos. Gubbins, ...Philadelphia, Pa.
Hendrickson & Dilatush, ...Robbinsville, N. J.
S. M. Hess & Bro., ...Fourth and Chestnut Sts., Philadelphia, Pa.
J. V. Higgins, ...Flemington, N. J.
Maretta Hill, ...Copper Hill, N. J.
Hires & Co., ...Quinton, N. J.
P. Hoffman & Bro., ...Raubsville, Pa.
The Hubbard Fertilizer Co., ...Merchants' Bank Bldg., Baltimore, Md.
International Seed Co., ...Rochester, N. Y.
Keystone Bone Fertilizer Co., ...540 Drexel Bldg., Philadelphia, Pa.
Samuel Lederer & Son, ...New Brunswick, N. J.
C. A. Lippincott & Bro., ...Moorestown, N. J.
Lister's Agricultural Chemical Works, ...Newark, N. J.
The Mapes F. and P. Guano Co., ...143 Liberty St., New York City.
The D. B. Martin Co., ...Broad and Chestnut Sts., Philadelphia, Pa.
Michigan Carbon Works, ...Detroit, Mich.
John E. Minch, ...Bridgeton, N. J.
Minch Bros., ...Bridgeton, N. J.
Monmouth Chemical Products Co., ...Farmingdale, N. J.
Jos. R. Moore, ...Swedesboro, N. J.
Muzzy Bros., ...Paterson, N. J.
Nassau Fertilizer Co., ...5 Beaver St., New York City.
Albert Nelson & Co., ...Allentown, N. J.
Northwestern Fertilizer Co., ...Chicago, Ill.
S. L. Pancoast, ...Mullica Hill, N. J.
S. F. Pennell, ...Bridgeton, N. J.
Peterson & Smith, ...Woodstown, N. J.
Rasin-Monumental Co., ...Baltimore, Md.
Reichard & Leidy, ...Middletown, N. Y.
John Repp, ...Glassboro, N. J.
M. F. Riley, ...Elmer, N. J.
Ruckman Bros., ...New Brunswick, N. J.
Scott Fertilizer Co., ...Elkton, Md.
Sharpless & Bro., ...Camden, N. J.
M. L. Shoemaker & Co., ...Delaware Ave. and Venango St., Philadelphia, Pa.
Rufus W. Smith, ...Elmer, N. J.
Shurts Bros., ...Neshanic Station, N. J.
Geo. F. Taylor Co., ...80 Pine St., New York City.
The Taylor Provision Company, ...Trenton, N. J.
Taylor Bros., ...Camden, N. J.
I. P. Thomas & Son Company, ...1000 Drexel Bldg., Philadelphia, Pa.
Trenton Bone Fertilizer Co., ...Trenton, N. J.
F. W. Tunnell & Co., ...15 N. Fifth St., Philadelphia, Pa.

The J. E. Tygert Company, ...28 S. Delaware Ave., Philadelphia, Pa.
Vineland Grain Co., ...Vineland, N. J.
A. J. Vreeland, ...Matawan, N. J.
Emil Wahl Manufacturing Co.,..3870 Pulaski Ave., Nicetown, Philadelphia, Pa.
Wallace Fertilizer Co., ...New York City, N. Y.
Geo. M. Wells, ...Moorestown, N. J.
Winterbottom, Carter & Co., ...Egg Harbor City, N. J.
Woodward & Dickerson, ...14 South Delaware Ave., Philadelphia, Pa.

Wholesale Prices of the Essential Elements of Plant Food for 1906.

The wholesale prices of the unmixed or raw materials used in preparing the mixed fertilizers are quoted weekly in the trade journal known as the "Oil, Paint and Drug Reporter." These prices have been recalculated, in order to express them as prices per pound of actual plant-food, which is the form adopted by the Experiment Stations of this country, and then tabulated for the entire year. On account of the fact that the report of the Station is made upon October 30th of each year, the prices that have been tabulated are for the year 1906.

WHOLESALE COST, PER POUND, IN NEW YORK.

MONTHS. 1906.	Of Nitrogen in form of						Of Phosphoric Acid in form of		Of Potash in form of							
	Nitrate of Soda.		Sulphate of Ammonia.		Dried Blood.		Acid Phosphate.		Kainit.		Muriate of Potash.		Double Sulphate of Potash and Magnesia.		High Grade Sulphate of Potash.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.
January, ...	14.1	14.0	15.2	15.1	16.1	15.8	3.38	3.0	3.4	3.4	3.92	3.86	4.61	4.49	4.55	4.49
February, ...	14.2	14.0	15.2	15.1	16.4	16.1	3.38	3.0	3.4	3.4	3.92	3.86	4.61	4.49	4.55	4.49
March, ...	14.3	14.2	15.1	15.0	16.8	16.7	3.38	3.0	3.38	3.38	3.92	3.86	4.58	4.46	4.54	4.48
April, ...	14.6	14.5	15.2	15.1	16.9	16.7	3.38	3.0	3.4	3.4	3.92	3.86	4.61	4.49	4.55	4.49
May, ...	14.8	14.6	15.2	15.1	16.6	16.4	3.38	3.0	3.4	3.4	3.92	3.86	4.61	4.49	4.55	4.49
June, ...	14.7	14.6	15.1	15.0	16.6	16.4	3.38	3.0	3.4	3.4	3.92	3.86	4.61	4.49	4.55	4.49
July, ...	14.9	14.7	15.0	14.9	16.4	16.3	3.38	3.0	3.4	3.4	3.92	3.86	4.61	4.49	4.55	4.40
August, ...	15.4	15.3	15.0	14.9	16.4	16.3	3.38	3.0	3.4	3.4	3.92	3.86	4.61	4.40	4.55	4.49
September, ...	16.1	16.1	15.1	15.0	16.4	16.3	3.38	3.0	3.4	3.4	3.92	3.86	4.61	4.49	4.55	4.49
October, ...	16.5	16.5	15.2	15.1	16.5	16.4	3.38	3.0	3.4	3.4	3.92	3.86	4.61	4.49	4.55	4.49
November, ...	16.4	16.2	15.5	15.5	16.8	16.6	3.38	3.0	3.4	3.4	3.92	3.86	4.61	4.49	4.55	4.49
December, ...	16.5	16.1	15.3	15.2	17.2	16.7	3.38	3.0	3.4	3.4	3.92	3.86	4.61	4.49	4.55	4.49
Average for 1906, ...	15.1		15.1		16.5		3.2		3.4		3.9		4.55		4.5	
Average for 1905, ...	14.9		15.0		15.8		3.2		3.4		3.9		4.5		4.5	
Average for 1904, ...	14.1		15.2		15.5		3.2		3.7		3.8		4.5		4.2	

Schedule of Trade Values.

As the manufacturers probably place most of their contracts for raw materials at the close of the year, the quotations for the last four months of 1906 and the first two months of 1907 have been averaged as a more suitable basis for the determination of the schedule of trade values for 1907.

From these wholesale prices as a basis, the following schedule was arranged at a meeting of the Station directors and chemists for use in Connecticut, Rhode Island, Massachusetts, Vermont, Maine and New Jersey during the year of 1907.

Schedule of Trade Values for 1907.

SCHEDULE OF TRADE VALUES ADOPTED BY EXPERIMENT STATIONS FOR 1907.

	Cents per pound.
Nitrogen in Nitrates,	18.5
" " Ammonia Salts,	17.5
Organic Nitrogen in dried and fine-ground fish, meat and blood, and in mixed fertilizers,	20.5
" Nitrogen in fine-ground bone and takage,	20.5
" Nitrogen in coarse bone and tankage,	15.0
Phosphoric Acid, soluble in water,	5.0
" " " " ammonium citrate*,	5.0
" " insoluble " fine bone and tankage,	4.0
" " " " coarse bone and tankage,	3.0
" " " " mixed fertilizers,	2.0
" " " " fine-ground fish, cotton-seed meal, castor pomace and wood ashes,.	4.0
Potash, as Muriate,	4.25
" " Sulphate, and in forms free from muriates (or chlorids),	5.0

* The solubility of phosphates, in ammonium citrate solutions, varies with the degree of heat. An act of the Legislature (see Laws of New Jersey, 1874, page 90), provides that in this determination the temperature used shall not exceed 100° Fahr.; in other States 150° Fahr. has been adopted. Consequently, the Station valuation of phosphoric acid, soluble in ammonium citrate has been fixed at *four and one-half cents* per pound for Connecticut, Massachusetts, Maine, Rhode Island and Vermont, and at *five cents* per pound in New Jersey.

Results of the Inspection.

Every brand examined this year was accompanied by a guarantee as required by law. A number of these guarantees, however, were defective in respect to phosphoric acid, either available or total phosphoric acid alone being given.

The quality of the fertilizers was excellent with a few exceptions. In 180 brands of complete fertilizers, nitrogen was found in the form of nitrates, 213 contained nitrogen in the form of ammonia salts, while in 83 brands both of these soluble forms of nitrogen was present.

There were 264 failures to reach the guarantee, distributed among 215 brands, 40 being deficient in two and four brands in all three ingredients. The number of deficiencies was 20.1 per cent. of those possible.

The average composition of the brands examined was as follows:

Total Nitrogen,	2.30 per cent.
Available Phosphoric Acid,	7.45 " "
Potash,	5.86 " "

The average valuation was $22.35 per ton, and the average selling price, $28.31, a difference of $5.96, or 26.6 per cent.

II.

INSPECTION OF CONCENTRATED FEEDS.

The results of the Station's seventh examination of the concentrated feeding stuffs sold in the State were printed in detail in bulletin 201.

Five hundred and twenty-eight samples were collected, of which 348, representing 160 different brands, required guarantees and 180 did not. Four hundred and seventy-one of the samples collected were selected for analysis, 304 of which belonged to the class that required a guarantee.

1907.

Guarantees and Actual Composition.

Of the 348 feeds collected which required a guarantee, 75 were not accompanied at the time of taking the samples. By correspondence with the manufacturer or dealer, the guarantees of these 75 samples, with two exceptions, were supplied to the Station. The filing of this information with the Station is not, however, a satisfactory substitute for a guarantee which is missing at the time of the sale of the feeds. In a great majority of the cases, however, the manufacturers are not at fault, for with few exceptions the samples represented brands which came to us from other sources properly guaranteed. It would seem, therefore, that the absence of the guarantee is frequently due to the carelessness of the dealer, and that the dealer is encouraged in this carelessness by the failure of many of its consumers to demand a guarantee before purchasing the feed offered for sale.

The following tabulation shows the classes of feeds in which one or more failed to reach the guarantee in protein or fat; over one-half of these deficiencies were due to excessive guarantees rather than the inferiority of the feed.

Feeds not Reaching Guarantees.

	Total Number of Samples.	Below in Protein.	Below in Fat.	Below in Protein and Fat.
Cottonseed Meal,	19	3	1	1
Linseed Meal,	18	2	....	.....
Penn Gluten Feed,	2	....	1	1
Buffalo Gluten Feed,	16	3	2	.....
Prima Gluten Feed,	4	1	2	1
Globe Gluten Feed,	6	1	....	.....
Piel Bros.' Gluten Feed,	2	2	....	.....
Corn Bran,	7	1	1	.....
Cerealine Feed,	2	1	....	.....
Hominy Meal,	23	....	2	1

	Total Number of Samples.	Below in Protein.	Below in Fat.	Below in Protein and Fat.
Biles' Fourex Grains,	2	1	....	.....
Continental Gluten Feed,	1	1	....	.....
Climax Distillers' Grains,	1	1	....	.....
Eagle Distillers' Grains,	1	1	....	.....
Hottelet's Rye Grains,	1	1	....	.....
Malt Sprouts,	16	4	2	.....
Dried Brewers' Grains,	36	....	5	1
Molasses Grains,	7	1	....	6
Sucrene Horse Feed,	2	....	1	.....
Blatchford's Calf Meal,	1	....	1	.....
Creamo Dairy Feed,	2	....	....	2
Sterling Stock Feed,	1	....	....	1
Prize Dairy Feed,	1	....	....	1
Hammond Dairy Feed,	3	....	1	.....
Cypher's Chick Food,	2	....	1	.....
Cypher's Forcing Food,	1	....	....	1
Cypher's Laying Food,	1	1	....	.....
Rice's Mixture,	1	....	....	1
H. O. Pigeon Feed,	1	1	....	.....
Ground Meat,	12	5	1	.....
Local Mixtures,	23	1	3	4
Totals,	215	32	24	21

There were seventy-seven deficient samples, thirty-two being low in protein, twenty-four in fat and twenty-one in both protein and fat.

The average composition of the several feeds, with their average selling price, examined this year is given in the following table, the feeds being arranged in order of their protein content:

	Protein. Per cent.	Fat. Per cent.	Fiber. Per cent.	Selling Price.
Cottonseed Meal,	39.70	8.96	7.39	$33 67
Linseed Meal,	33.80	7.67	7.06	34 43
Climax Distillers' Grains,	32.25	12.99	10.73	30 00
Biles' Fourex Grains,	31.97	12.83	12.08	26 00
Continental Gluten Feed,	31.19	15.49	6.26	28 00
Buckwheat Middlings,	30.46	7.79	2.89	22 07
Globe Gluten Feed,	26.38	3.21	6.48	27 00
Dried Brewers' Grains,	26.24	6.99	12.56	22 37
Biles' Ready Ration,	26.00	7.71	6.14	30 00
Malt Sprouts,	25.76	1.48	11.77	20 60
Warner's Gluten Feed,	24.88	4.13	6.43	28 25
Piel Bros.' Gluten Feed,	24.85	3.15	6.23	25 90
Buffalo Gluten Feed,	24.42	3.17	6.36	26 70
Buckwheat Bran,	23.52	6.62	2.39	23 00
Prima Gluten Feed,	23.03	3.20	6.81	27 50
Curled Cocoanut Fiber,	22.75	10.80	8.44	......
Queen Gluten Feed,	22.69	3.58	5.75	29 00
Eagle Distillers' Grains,	22.13	9.11	12.37	25 00
Buffalo Creamery Feed,	22.00	4.69	10.01	28 00
Sugarine Dairy Feed,	20.34	4.65	8.62	23 50
Protena Dairy Feed,	20.31	3.56	15.67	24 50
Algrane Butter Feed,	19.85	5.09	10.13	26 50
Sucrene Dairy Feed,	18.34	5.40	9.22	23 67
Hammond Dairy Feed,	17.25	4.32	9.30	23 50
Feeding Flour,	17.23	4.87	1.58	28 90
Penn Gluten Feed,	16.69	7.33	3.20	25 50
Wheat Middlings,	16.39	4.88	4.54	25 50
Molasses Grains,	16.32	1.87	7.62	22 14
Wheat Feed,	16.15	5.02	6.53	23 73
Buckwheat Feed,	16.06	3.75	18.50	17 36
Algrane Milk Feed,	15.88	4.64	8.61	28 00
Pure Rye Grains,	15.81	7.79	13.00	22 00
Alfalfa Meal,	15.55	2.28	26.61	31 00
Rye Middlings,	15.44	3.23	3.07	23 67
Wheat and Rye Bran,	15.00	4.54	7.81	23 50
Wheat Bran,	14.89	4.74	9.00	24 17
Rye Bran,	14.77	2.95	3.20	20 75
Barley Feed,	14.44	4.81	10.34	21 50
Prize Dairy Feed,	14.44	1.32	6.69	22 00
Quaker Dairy Feed,	14.35	4.02	14.13	23 31
Creamo Dairy Feed,	14.32	3.90	15.58	27 25
Sucrene Horse Feed,	13.60	3.38	7.63	24 00
Buffalo Horse Feed,	13.06	4.75	8.76	24 00
Algrane Horse Feed,	12.41	4.54	9.85	28 00
Bread Refuse,	12.00	1.99	0.33	20 00
Ground Oats,	11.85	4.97	9.68	30 00
Eclipse Feed,	11.82	5.50	4.90	24 00
Sucrene Horse, Mule and Ox Feed,	11.63	3.74	9.71	25 00

	Protein. Per cent.	Fat. Per cent.	Fiber. Per cent.	Selling Price.
Cream of Oats,	11.50	5.52	8.34	......
Cracker Refuse,	11.06	1.13	0.66	16 00
Schumacher's Stock Feed,	11.04	4.40	9.05	25 00
Sterling Stock Feed,	10.82	3.12	8.26	25 00
Hominy Meal,	10.38	9.26	3.20	24 83
Corno Horse and Mule Feed,	10.06	3.56	12.16	28 00
Ground Wheat,	10.06	1.82	1.68	......
Corn Bran,	9.86	7.17	7.64	24 17
Buffalo XXX Stock Feed,	9.75	5.68	7.16	26 00
Maizeline Feed,	9.63	8.91	7.15	26 50
Ground Rye,	9.63	1.34	1.12	......
Cerealine Feed,	9.29	7.17	7.81	24 00
Star Hominy Feed,	9.29	6.59	8.46	23 67
Rye Feed,	9.19	1.55	1.27	23 33
Corn and Oats,	9.17	3.71	2.84	24 33
DeFi Corn and Oat Feed,	8.88	3.53	11.36	23 00
Victor Feed,	8.56	4.56	10.78	23 57
Boss Chop Feed,	8.44	4.31	8.11	23 00
Monarch Chop Feed,	8.44	3.59	7.00	23 00
Corn Meal,	8.41	3.76	....	23 46
Buffalo Corn and Oat Feed,	8.41	3.87	12.51	24 00
Dried Beet Pulp,	8.32	0.73	16.99	21 10
Cob Meal,	8.03	3.35	5.43	21 50
Jim Dandy Oat Feed,	7.91	3.31	22.02	16 00
Vim Feed,	7.23	2.41	25.29	17 25
Friends' Oat Feed,	6.50	2.50	23.89	18 00
Royal Oat Feed,	6.38	2.73	23.15	16 40

Ground Meat, Calf Meal and Poultry Foods.

	Protein. Per cent.	Fat. Per cent.	Fiber. Per cent.	Selling Price.
Poultry Meat,	53.71	16.32	....	*$2 61
Animal Meal,	32.48	20.49	....	2 35
Blatchford's Calf Meal,	27.06	4.43	4.37	3 50
Leader Beef Biscuit,	23.19	4.20	0.43	......
Rice's Mixture,	18.13	5.80	4.72	2 00
Algrane Poultry Feed,	17.96	5.86	5.25	1 86
Sucrene Poultry Feed,	17.50	5.53	8.25	1 90
Cypher's Laying Food,	16.06	3.98	3.39	1 85
American Poultry Feed,	13.69	5.77	3.54	1 65
Star Chick Feed,	13.31	5.81	3.94	2 50
H. O. Pigeon Feed,	12.13	2.60	1.96	2 25
Algrane Scratching Feed,	11.56	3.33	2.70	2 00
Cypher's Scratching Feed,	11.56	3.38	2.01	1 76
Cypher's Developing Food,	11.38	2.73	1.70	1 76
Purina Chick Feed,	11.32	3.90	2.91	2 25
Purina Scratch Food,	10.88	3.77	2.84	2 15
Cypher's Forcing Food,	10.75	3.04	2.15	1 85
Cypher's Chick Food,	10.06	3.12	2.25	2 25

* Selling price per cwt.

This tabulation confirms the statement made in previous reports and bulletins that the price alone gives but little indication of the feeding value of a feed. For instance, certain feeds containing 32, 25, 20, 16 and 10 per cent. of protein, respectively, have the uniform selling price of about $26 per ton. If protein is the nutrient needed it is very apparent that the economy of the purchase will depend upon the selection of the feed.

In order to consider the different feeds on a more comparable basis, the following tables have been prepared in which are shown the actual quantity of protein and fat which was purchased in the different feeds for one dollar.

Pounds of Protein and Fat Obtained in Guaranteed Protein Feeds, Containing 15 or More Per Cent. Protein, for One Dollar, at Current Prices:

FEED.			FEED.		
Group I. (30–40 Protein).	Protein.	Fat.	*Group II. (Con.)*	Protein.	Fat.
Cottonseed Meal,	23.6	5.3	Queen Gluten Feed,	15.6	2.5
Linseed Meal,	19.7	4.5	Eagle Distillers' Grains,	17.7	7.3
Biles' Fourex Grains,	24.6	9.9	Buffalo Creamery Feed,	15.7	3.4
Climax Distillers' Grains,	21.5	8.7	Sugarine Dairy Feed,	17.4	4.0
Continental Gluten Feed,	22.3	11.1	Protena Dairy Feed,	16.2	2.8
			Algrane Butter Feed,	15.0	3.9
Group II. (20–27 Protein).					
Globe Gluten Feed,	19.5	2.4	*Group III. (15–18 Protein).*		
Dried Brewers' Grains,	23.6	6.3	Sucrene Dairy Feed,	15.5	4.6
Biles' Ready Ration,	17.3	5.1	Hammond Dairy Feed,	14.7	3.7
Malt Sprouts,	25.0	1.4	Penn Gluten Feed,	13.1	5.8
Warner's Gluten Feed,	17.6	2.9	Molasses Grains,	14.8	1.7
Piel Bros.' Gluten Feed,	19.4	2.5	Algrane Milk Feed,	11.3	3.3
Buffalo Gluten Feed,	18.4	2.4	Pure Rye Grains,	14.4	7.1
Prima Gluten Feed,	16.8	2.3			

Pounds of Protein and Fat Obtained in Unguaranteed Feeds for One Dollar, at Current Prices.

FEED.	Protein.	Fat.	FEED.	Protein.	Fat.
Wheat Bran,	12.4	4.0	Buckwheat Bran,	20.5	5.8
Wheat Middlings,	12.9	3.8	Buckwheat Middlings,	27.7	7.1
Wheat Feed,	13.7	4.3	Buckwheat Feed,	18.7	4.4
Feeding Flour,	12.0	3.4	Corn Meal,	7.2	3.2
Wheat and Rye Bran,	12.8	3.9	Corn and Cob Meal,	7.5	3.1
Rye Bran,	14.3	2.9	Corn and Oats,	7.6	3.1
Rye Middlings,	13.1	2.7	Ground Oats,	7.9	3.3
Rye Feed,	7.9	1.3	Alfalfa Meal,	10.0	1.5

The results of the inspection may be summarized as follows:

1. Of the 160 different brands of feed received, and which should have been guaranteed, two failed to meet the requirement.

2. Of the 304 samples which were guaranteed, seventy-seven were deficient, fifty-three being low in protein.

3. Of the 167 samples which did not require a guarantee, all were pure products, but the wheat brans and feeding flours were below normal quality.

4. No direct adulteration is reported, but the inferiority of cottonseed meal this year, and the poor quality of certain molasses grains and alfalfa meals, are worthy of notice.

5. Certain feeds of good quality still bear guarantees higher than their composition warrants.

6. The variability in composition of certain high-grade feeds and the absence of a corresponding variation in selling price demands that a strict regard must be given to the prices asked, as well as to the amount of nutrients guaranteed.

7. The cheapest protein feeds this year were buckwheat middlings, malt sprouts, dried brewers' grains, high-grade distillers' grains and cottonseed meal.

Market Prices of Commercial Feeds.

Kind of Feed.	Average for the Six Months Preceding May 1, 1903	May 1, 1904	May 1, 1905	May 1, 1906	May 1, 1907
Cottonseed Meal,	$29 85	$29 87	$29 25	$29 73	$33 67
Linseed Meal,	32 27	30 71	32 44	33 84	34 43
Gluten Feeds,	25 81	25 73	25 46	25 96	27 00
Hominy Meal,	25 62	23 89	24 88	23 45	24 83
Maizeline Feed,	26 50	24 91	26 00	25 25	26 50
Corn Bran, or Sugar Feed,	20 17	21 73	22 13	20 58	24 17
Corn Meal,	.....	24 62	25 48	24 63	23 46
Corn and Oats,	28 57	23 83	25 48	26 83	24 33
Cob Meal,	.....	.....	.....	19 50	21 50
Friends' Oat Feed,	.....	17 00	17 33	15 00	18 00
Royal Oat Feed,	16 57	16 60	16 08	14 78	16 40
Vim Oat Feed,	15 60	16 00	17 00	15 71	17 25
Wheat Feed,	22 26	23 18	24 59	21 47	23 73
Wheat Bran,	22 12	22 64	24 31	20 61	24 17
Wheat Middlings,	25 28	26 71	26 71	24 31	25 50
Feeding Flour,	27 40	27 75	29 13	26 27	28 90
Rye Bran,	.....	.....	22 00	19 00	20 75
Rye Middlings,	24 25	.....	26 00	22 00	23 67

Kind of Feed.	Average for the Six Months Preceding May 1, 1903	May 1, 1904	May 1, 1905	May 1, 1906	May 1, 1907
Rye Feed,	24 36	.....	25 00	22 50	23 33
Buckwheat Middlings,	20 40	22 50	21 12	20 87	22 07
Buckwheat Bran,	18 67	18 05	21 43	17 00	23 00
Buckwheat Feed,	15 00	16 00	.....	15 00	17 36
Barley Feed,	26 00	25 00	24 63	21 00	21 50
Dried Distillers' Grains,	18 50	23 67	25 57	27 13	27 50
Malt Sprouts,	18 69	19 19	21 08	20 22	20 60
Dried Brewers' Grains,	20 06	21 21	22 72	22 04	22 37
Molasses Grains,	20 50	20 71	20 88	20 93	22 14
Buffalo Creamery Feed,	.....	.....	27 50	28 00	28 00
Algrane Butter Feed,	*29 33	*29 00	*29 50	*28 00	26 50
Algrane Horse Feed,	**30 00	**29 33	**29 17	**27 40	28 00
Sucrene Dairy Feed,	.....	.....	24 00	24 09	23 67
Quaker Dairy Feed,	20 44	22 78	23 67	22 00	23 31
Shumacher's Stock Feed,	28 67	26 20	26 60	24 00	25 00
Victor Corn and Oat Feed,	22 90	22 55	22 86	21 33	23 57
Protena Dairy Feed,	.....	.....	23 45	25 00	24 50
Alfalfa Meal,	.....	.....	.....	26 00	31 00
Dried Sugar Beet Pulp,	.....	18 50	22 00	20 33	21 10
Hammond Dairy Feed,	.....	.....	.....	.....	23 50
Creamo Dairy Feed,	.....	.....	.....	.....	27 25
Sugarine Dairy Feed,	.....	.....	.....	.....	23 50
Sucrene Horse Feed,	.....	.....	.....	.....	24 00
Jim Dandy Oat Feed,	.....	.....	.....	.....	16 00
Corno Horse and Mule Feed,	.....	.....	.....	27 00	28 00

III.

INSPECTION OF PARIS GREEN.

The Station received twenty-two applications from manufacturers and wholesale dealers, for certificates which would authorize the party receiving it to deal in Paris green. The applications having been made in accordance with the law of April 9, 1906, the certificates were granted to the following:

Manufacturers.

Adler Color & Chemical Co., ... New York City.
The Jas. A. Blanchard Co., ... New York City.
Chas. M. Childs & Co., ... New York City.

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*Sold as H. O. Dairy Feed.
** Sold as H. O. Horse Feed.

F. A. DeVoe & C. T. Raynolds Co., ...New York City.
Morris Herrman, ...68 William St., New York City.
F. L. Lavanburg, ...New York City.
John Lucas & Co., ...Gibbsboro, N. J.
Sherwin & Williams Co., ...Newark, N. J.

Dealers.

Name.	*Brands sold.*
Alpha Chemical Co.,	Adler, Berger, DeVoe & Raynolds, Pfeiffer.
Geo. M. Andrews,	Ansbacher.
C. H. Butterworth Drug and Paint Co.,	Lucas.
E. J. Barry,	Adler, Berger, DeVoe & Raynolds, Pfeiffer.
Jas. Cooper, Jr.,	Leggett.
Felton, Sibley & Co.,	Pfeiffer.
Samuel H. French & Co.,	Ansbacher.
J. J. Hockinjos Co.,	DeVoe & Raynolds.
C. S. Littell & Co.,	Adler, Ansbacher, Barry, Herrman, Lavanburg, Pfeiffer.
Leggett & Bro.,	Adler, Herman, Pfeiffer.
Lehn & Fink,	Pfeiffer.
H. B. Semple & Son,	Adler, Berger, DeVoe & Raynolds, Pfeiffer.
Steelman & Archer,	Blanchard, Lavanburg, Pfeiffer.
Wetherill & Co.,	Herrman and Pfeiffer.

Twenty-nine samples were received, eighteen being collected by a representative of the Station and eleven were sent in by granges and individuals at the Station's request. The results were published in bulletin 205.

Pure Paris green should contain an equivalent to:

Arsenious Oxid,	58.65%
Copper Oxid,	31.29%
Acetic Acid,	10.06%

The ratio of the copper oxid to the arsenious oxid is 1.00 to 1.87. This ratio is important in assisting to determine whether white arsenic had been added, either purposely or otherwise. White arsenic cannot be present without changing the relative proportions of these constituents.

The following is a summary of the results obtained:

1. Twenty-nine samples were analyzed, all but one of which were guaranteed as required by law. This unguaranteed sample, however, was of good quality.

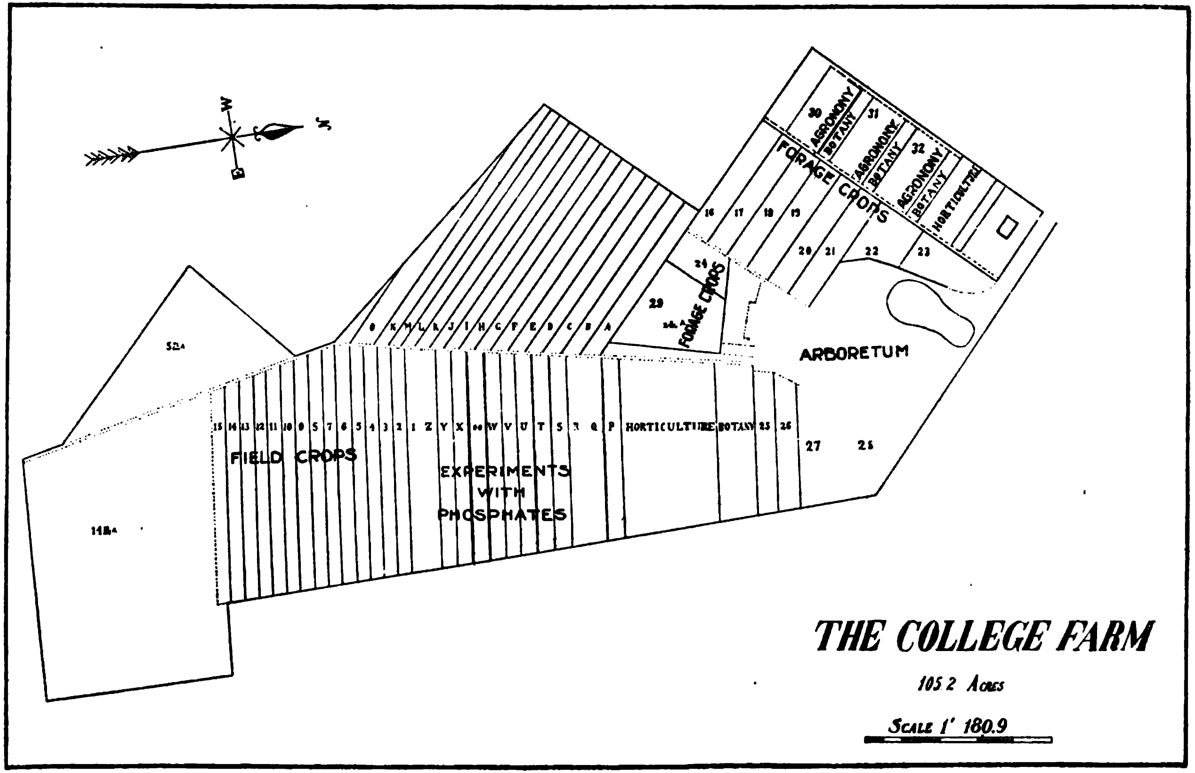
2. Twenty-three samples were high grade.

3. One sample did not reach the 50 per cent. limit of arsenious oxid combined with copper.

4. The average of the twenty-nine samples:

	Per cent.
Total Arsenious Oxid,	57.31
Water Soluble Arsenic Compounds,	1.98
Copper Oxid,	29.73
The ratio of the Copper Oxid to the Arsenious Oxid,... 1.00 to	1.93

REPORT OF DAIRY HUSBANDMAN.


THE COLLEGE FARM
105.2 Acres
Scale 1' 180.9
FIELD CROPS
EXPERIMENTS WITH PHOSPHATES
HORTICULTURE
BOTANY
ARBORETUM
FORAGE CROPS
AGRONOMY
HORTICULTURE
N
E
W

Report of the Dairy Husbandman.

GEO. A. BILLINGS.

FEEDING EXPERIMENTS.

Distillers' Grains vs. Ground Oats, Gluten Feed, Oil Meal and Bran.

In compounding a feed ration for milch cows several things have to be taken into consideration, namely, the amount of digestible protein, fat and carbohydrate, the relative proportion of light and heavy feed, or what is known as the bulkiness of the ration, palatability and cost. Dairymen are very prone to overlook the latter and use a variety of high-priced concentrates, irrespective of cost, with the object of getting a ration palatable and efficient in milk production. In view of the recent high prices for feeds, and especially bran, an experiment has been conducted with a feed ration, chiefly of high-grade dried corn distillers' grains, using as little as possible of bran and depending on the corn silage for carbohydrate. This was compared with a standard feed ration, including ground oats, gluten feed, oil meal and bran. The object, briefly summarized, was to study the effect of a large amount of dried corn distillers' grains in the ration as follows:

1. Palatability of this feed and influence on the individual animals.
2. Yield of milk and butter.
3. Quality of milk and butter.
4. Cost of producing milk and butter.

General Plan.

Four animals were selected as near as possible in the same period of lactation and equally good feeders. These animals

were divided into lots of two each, Lot I. receiving the standard ration and Lot II. the distillers' grains ration in Period I., while in Period II. the order was reversed. The periods were of forty-five days each with five to eight days of preliminary feeding in the beginning and transition between periods.

The care and handling of the animals, weighing of feeds, feeding and sampling and testing of milk was done in the same manner and with the same care as in previous feeding experiments. The animals were weighed at the beginning and end of each period.

Rations Fed.

The roughage fed in the experiment was the same in both periods, namely, corn silage, of good quality, with very little acid, high per cent. of dry matter and a good proportion of ears. The pea and oat hay was well cured with a large per cent. of pea vine and palatable. The corn stalks were fed cut in three-inch pieces and only the bare butts refused. This refuse was accounted for in the calculated ration. The feed ration was mixed at the beginning of each period in the following proportions:

	Standard.	*Distillers' Grains.*
Ground Oats,	150 lbs.	...
Wheat Bran,	300 "	...
Gluten,	300 "	...
O. P. Oil Meal,	100 "	...
Dried Beet Pulp,	100 "	...
Dried Distillers' Grains,		600 lbs.
Wheat Bran,		100 "
Dried Beet Pulp,		100 "

The amount of mill feed consumed varied with the size and feeding capacity of the animal and varied from 9 to 11 lbs. daily per animal with the standard ration and 8 to 9½ lbs. with the distillers' grains ration. The average daily ration fed each animal was as follows:

Period I.

	Lot I.		Lot II.	
	Roma.	*Cherry's Lassie.*	*Sebolt 5th.*	*Diana.*
Corn Silage,	45 lbs.	35 lbs.	35 lbs.	35 lbs.
Oat and Pea Hay,	5 "	5 "	4 "	4 "
Corn Stalks,	5 "	5 "	5 "	5 "
Feed Mixture,	11 "	9½ "	8½ "	4 "
as follows:				
Ground Oats,	1.73 "	1.50 "	.....	.....
Wheat Bran,	3.47 "	3.00 "	.....	.....
Gluten Feed,	3.47 "	3.00 "	.....	.....
Oil Meal,	1.16 "	1.00 "	.....	.....
Dried Beet Pulp,	1.16 "	1.00 "	.....	.....
Dried Distillers' Grains,			6.38 "	6.00 "
Wheat Bran,			1.06 "	1.00 "
Dried Beet Pulp,			1.06 "	1.00 "

Period II.

The feed mixture was made with the same proportion of feeds as Period I. The average daily ration was as follows:

	Sebolt 5th.	*Diana.*	*Roma.*	*Cherry's Lassie.*
Corn Silage,	35 lbs.	35 lbs.	41 lbs.	33 lbs.
Oat and Pea Hay,	3 "	3 "	4 "	4 "
Corn Stalks,	5 "	5 "	5 "	5 "
Feed Mixture,	9 "	9 "	9½"	8½"

The feeds were well up to the average, as the following figures for protein will show:

Linseed Meal,	32.63%
Wheat Bran,	15.31 "
Dried Beet Pulp,	8.63 "
Dried Distillers' Grains,	32.44 "
Gluten Feed,	24.63 "
Ground Oats,	12.38 "

The digestible nutrients in the average daily ration as outlined above is represented in Table I.

TABLE I.

Standard Ration.

AVERAGE DAILY RATION.	Amount Fed.	Total Dry Matter.	Digestible Nutrients. Protein.	Fat.	Carbohydrates.	Total (fat x 2¼).
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Corn Silage,	37.50	10.52	0.338	0.33	5.86	6.938
Oat and Pea Hay,	4.00	3.30	0.356	0.06	1.51	2.006
Corn Stalks,	5.00	1.73	0.074	0.02	0.82	0.944
Ground Oats,	1.52	1.32	0.152	0.06	0.79	1.082
Bran,	3.04	2.64	0.370	0.08	1.18	1.730
Gluten Feed,	3.04	2.78	0.636	0.08	1.64	2.456
Oil Meal,	1.02	.92	0.305	0.06	0.33	0.775
Dried Beet Pulp,	1.02	.92	0.058	....	0.69	0.743
Total,	....	24.13	2.284	0.69	12.82	16.674

Nutritive ratio, 1:6.2

Distillers' Grain Ration.

Corn Silage,	36.00	10.11	0.324	0.32	5.63	6.674
Oat and Pea Hay,	4.00	3.30	0.356	0.06	1.51	2.006
Corn Stalks,	5.00	1.73	0.074	0.02	0.82	0.994
Dried Distillers' Grains,	6.48	5.96	1.555	0.75	2.49	5.735
Dried Beet Pulp,	1.08	1.01	0.058	....	0.76	0.818
Bran,	1.08	0.96	0.132	0.03	0.48	0.682
Total,	....	23.07	2.499	1.18	11.64	16.859

Nutritive ratio, 1:5.

This experiment was to study the effect in feeding a large amount of distillers' grains, hence, 6½ lbs. of this feed was fed daily with but one pound of bran and one pound of dried beet pulp. This made the nutritive ratio 1 :5 and the ration narrower than the standard ration. The dry matter in both rations, 23 to

24 lbs. was ample to satisfy the animals and 2.28 to 2.49 lbs. of digestible protein, daily per cow, would not necessarily force the animal, yet be sufficient and economical for milk production. The total digestible nutrients fed daily averaged 16.5 lbs. The kind and amount of roughage was practically the same in both rations.

I. PALATABILITY AND INFLUENCE ON INDIVIDUAL ANIMALS.

At no time did any of the animals refuse the distillers' grains, in fact, they seemed quite as eager for this ration as for the one with greater variety of feeds. These grains consist largely of the gluten from corn with the corn bran which makes them more bulky, hence safer to feed and nearly as digestible as gluten feed. In this respect they are more desirable than dried brewers' grains, which contain a larger amount of indigestible matter.

The influence on the individual animal in respect to general appearance and maintenance of flesh was favorable to the distillers' grain ration. The weights of the animals were as follows:

	Standard Ration.		Distillers' Grain Ration.
Beginning of Period I.			
Roma,	1,225		....
Cherry's Lassie,	1,000		....
Sebolt,			875
Diana,			1,025
At Change of Ration.			
Roma,	....	1,103	....
Cherry's Lassie,	....	998	....
Sebolt,	....	848	....
Diana,	....	968	....
At End of Experiment.			
Roma,	....		1,210
Cherry's Lassie,	....		1,000
Sebolt,	870		....
Diana,	1,020		....

The variation in weight from beginning to end of experiment was very slight. All the animals decreased in weight during the first period. The large milk yield at this time may explain this,

but as they decreased in milk flow from advance of lactation they gradually assumed their normal weight. There was practically no difference in the influence of the two rations in this respect.

Yield of Milk and Butter.

Table II gives the weekly record of milk and fat including the fat test of the milk. With the exception of Diana all the cows freshened about the same time; this cow freshened about two months earlier. Notwithstanding the fact that the cows were in good condition at the beginning of the experiment and were well fed during both periods, Roma and Cherry's Lassie show respectively 19.6% and 14.5% shrinkage in the total amount of milk from Period II on the distillers' grains ration, while Sebolt and Diana 27.8% and 3.2% respectively on the standard ration or an average for all cows on both rations for 45 days of 16.3%. These results are high for the average natural shrinkage due to lactation and to some extent must be attributed to the individuality of the cows. The yearly records of Sebolt especially, show a material decrease of milk from the second to fourth period of lactation. The average shrinkage in amount of fat in 45 days was 12.8%.

TABLE II.

Yield of Milk and Butter.

LOT I. PERIOD I.	STANDARD RATION. Roma. Milk.	Fat.	Fat.	Cherry's Lassie. Milk.	Fat.	Fat.	DISTILLERS' GRAINS RATION. LOT II. Sebolt. Milk.	Fat.	Fat.	Diana. Milk.	Fat.	Fat.
	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.
January 4—January 10, ...	205.6	4.4	9.046	205.8	3.7	7.615	223.1	5.4	12.047	163.7	4.6	7.530
" 11— " 17, ...	206.2	4.2	8.660	204.6	3.8	7.775	209.6	5.2	10.899	161.2	4.3	6.932
" 18— " 24, ...	200.8	4.2	8.434	199.4	3.7	7.378	191.7	5.2	9.968	174.9	4.1	7.171
" 25— " 31, ...	189.9	4.4	8.356	195.4	4.0	7.816	177.3	5.0	8,865	179.0	4.3	7.697
February 1—February 7, ...	188.3	4.2	7.908	191.6	3.8	7.281	171.3	5.1	8.736	174.3	4.0	6.972
" 8— " 14, ...	185.0	4.2	7.770	190.8	3.8	7.250	167.8	5.0	8.390	171.0	4.2	7.182
" 15— " 17, ...	81.2	4.8	3.572	81.7	4.1	3,350	69.1	5.2	3.593	73.9	4.1	3.030
Total, ...	1257.0		53.746	1269.8		48.465	1209.9		62.498	1096.0		46.514
Daily Average, ...	27.9	4.27	1.194	28.2	3.82	1.077	26.9	5.16	1.389	24.4	4.24	1.033
PERIOD II.	DISTILLERS' GRAINS RATION.						STANDARD RATION.					
February 28—March 6, ...	170.7	4.6	7.852	183.6	3.9	7.160	146.6	4.9	7.183	165.3	4.3	7.108
March 7—March 13, ...	166.5	4.6	7.659	181.2	4.1	7.429	139.9	4.8	6.715	167.1	4.1	6.851
" 14— " 20, ...	165.0	4.6	7.590	177.0	4.2	7.434	140.0	5.2	7.280	164.0	4.4	7.216
" 21— " 27, ...	161.0	5.0	8.050	167.5	4.0	6.700	133.5	5.1	6.808	165.7	4.4	7.449
" 28—April 3, ...	152.1	4.6	6.997	166.1	4.1	6.810	132.4	4.8	6.355	169.3	4.1	6.941
April 4— " 10, ...	135.9	5.0	6.795	148.7	4.1	6.097	125.0	4.9	6.125	161.9	4.3	6.961
" 11— " 13, ...	58.8	5.2	3,058	63.4	4.2	2.663	55.2	5.3	2.925	71.4	4.4	3.142
Total, ...	1010.00		47.981	1087.5		44.293	872.6		43.391	1064.7		45.668
Daily Average, ...	22.4	4.75	1.066	24.1	4.07	.984	19.4	4.97	.964	23.6	4.29	1.015

TABLE III.

Summary of Yield.

Lot I.	Standard Ration.				Distillers' Grains Ration.			
	Milk.	Fat.	Fat.	Butter.	Milk.	Fat.	Fat.	Butter.
	lbs.	%	lbs.	lbs.	lbs.	%	lbs.	lbs.
Roma, ...	1257.0	4.27	53.746	62.704	1010.0	4.75	47.981	55.978
Cherry's Lassie, ...	1269.3	3.82	48.465	56.543	1087.5	4.07	44.293	51.675
Total, ...	2526.3		102.211	119.247	2097.5		92.274	107.653
Lot II.								
Sebolt, ...	872.6	4.97	43.391	50.628	1209.9	5.16	62.498	72.914
Diana, ...	1064.7	4.29	45.668	53.279	1098.0	4.24	46.514	54.266
Total, ...	1937.3		89.059	103.902	2307.9		109.012	127,180
Total, Lots I and II, ...	4463.6		191.270	223.149	4405.4		201.286	234.833
Daily average per cow,...	24.80	4.28	1.063	1.240	24.47	4.57	1.118	1.304

The summary of the experiment, as outlined in Table III., gives a total 4,463.6 lbs. and a daily average of 24.8 lbs. of milk from the standard ration, while the distillers' grains ration produced a total of 4,405.4 lbs. and a daily average of 24.47 lbs. of milk. This gave a gain of only 1.34% from the former ration. In yield of fat the gain was 5.2% from the distillers' grains ration. If we cut out of the experiment Sebolt and Roma, whose records show such a great falling off in yield and comparing Cherry's Lassie and Diana through Periods I. and II. it will be found that the gain from the standard ration amounted to 6.79% in milk and 3.6% in fat.

Cost of Milk and Butter.

In computing the cost of producing milk and butter from these rations the following valuations per ton were put on the feeds, based on the selling price as found in different parts of the State at the time the experiments were conducted.

Climax Distillers' Grains,	$29 00
Dried Beet Pulp,	21 00
Wheat Bran,	24 00
Ground Oats,	30 00
Gluten Feed,	28 00
Oil Meal,	36 00
Corn Silage,	4 00
Corn Stalks,	4 00
Oat and Pea Hay,	16 00

TABLE IV.

Yield and Cost of Milk and Butter Produced.

Rations Fed.	Number days of experiment.	Total Digestible Nutrients.	Cost of Daily Ration.	Average Daily Yield Per Cow.				Cost to Produce.				100 lbs. of Digestible Nutrients Cost.
				Milk.	Fat.	Fat.	Butter.	100 lbs. of Milk.	1 qt. of Milk.	1 lb. of Fat.	1 lb. of Butter.	
		lbs.	cts.	lbs.	%	lbs.	lbs.	cts.	cts.	cts.		
Standard Ration, ...	90	16.67	28.39	24.80	4.28	1.063	1.240	114.4	2.45	26.7	22.9	$1.70
Distiller's Grains Ration,.	90	16.86	23.20	24.47	4.57	1.118	1.304	94.8	2.08	20.7	17.8	1.87

The cost of the average daily ration as outlined in Table I. was 28.39 cents for the Standard ration and 23.2 cents for the Distillers' Grains ration or a saving in cost of 5.19 cents per day or 18.3% from the latter ration. The cost of producing milk and butter, not including labor, as outlined in Table IV. is as follows:

	Standard Ration. cts.	Distillers' Grain Ration. cts.
100 lbs. Milk,	114.4	94.8
1 qt. Milk,	2.45	2.03
1 lb. Fat,	26.7	20.7
1 lb. Butter,	22.9	17.8

In other words, the gain from a feed ration, largely of dried distillers' grains in place of a feed ration containing a mixture of ground oats, bran, gluten, beet pulp and oil meal, taking into consideration the cost of production, was 20.6% from milk and 28.6% from butter. These results show the advantage of greater care in the selection of feeds for the dairy. As a rule, where sufficient roughage is grown on the farm, it is better to buy concentrates giving the greatest amount of digestible protein for money expended. Hence, in compounding the ration, aim to eliminate those feeds of low feeding value yet high in price, at the same time preserving the general character of the ration in respect to palatability and bulkiness.

Eliminating the two cows Roma and Sebolt from the experiment as suggested under previous heading, the average daily yield for the two periods is 25.9 lbs. of milk and 1.046 lbs. of fat from the standard ration and 24.3 lbs. of milk and 1.009 lbs. of fat from the distillers' grains ration. These results would give the cost of milk and butter as follows:

	Standard Ration. cts.	Distillers' Grain Ration. cts.
100 lbs. Milk,	109.6	95.5
1 lb. Butter,	27.1	23.0

The saving in cost of production from the distillers' grain ration would be 14.8% and 17.8% respectively for milk and butter, a gain sufficiently striking to be of considerable importance to dairy men.

Quality of Milk and Butter.

A composite sample of milk was secured and the amount taken at each milking was an aliquot of the total yield. A sampling tube was used and seven days' samples preserved and tested for fat by the Babcock test. It is probable that the temperature and environment may have caused the small variations as recorded in Table II., but Sebolt's record shows a decided drop in the per cent. of fat in the change from the distillers' grains ration to the standard ration, when naturally the test would have increased

with the decrease in yield of milk. The increase in fat from Roma and Cherry's Lassie in Period II. is no more than might be expected from the advanced period of lactation. While the daily average in fat test as given in Table III. gives 0.29% increase from the distillers' grain ration, if we compare the records of Cherry's Lassie and Diana alone through the two periods we get a gain of 0.12% in fat and for the experiment a total of 94.1 lbs. of fat from the standard ration and 90.8 from the distillers' grains ration, or 3.6% gain from the standard ration. From these results a conclusion cannot be drawn except to say that the average quality of milk can be maintained from a ration largely of distillers' grains. The butter made from the distillers' grains ration was firm, of good flavor and texture and very marketable.

Summary.

1. A ration having a large amount of dried distillers' grains was very palatable and the animals maintained their thrifty condition.

2. There was a gain of only 1.34% in yield of milk from the standard ration, and 5.2% in yield of butter from the distillers' grains ration. If the records of two cows are compared instead of four, there is 6.8% gain in milk and 3.6% gain in butter from the standard ration.

3. The Standard daily ration cost 28.39 cents per cow, and the distillers' grains ration 23.2 cents. One hundred lbs. of milk cost 19.6 cents, 1 qt. of milk 0.42 cents, and 1 lb. butter 5.1 cents less from the latter ration or a net saving of 20.6% from milk and 28.6% from butter in cost of production. These savings are respectively 14.8% and 17.8%, if we take the records of two cows instead of four.

4. While there is apparently a decided gain in the quality of milk from the feeding of distillers' grains, if we eliminate the records of two cows, the records of the other two show but a small gain in the fat test. The butter produced from the dried distillers' grains ration was firm, of good quality and very marketable.

Soiling Crops vs. Silage and Oat and Pea Hay.

In order to study the problem of summer feeding of dairy cattle, to see if corn silage can be used as a substitute for forage crops or pasturage in furnishing the roughage of the ration, a preliminary experiment was conducted a year ago and reported in Bulletin 204. This experiment has been continued using four cows instead of the whole herd as before, and careful records made of the yield of milk and butter and the cost of each ration. Cows were selected that produced, daily, nearly the same quantity of milk. The animals were divided into lots of two each. The experiment divided into two periods of 15 days each, allowing seven days between for the changing of the rations. In Period I., Lot I., Diana and Princessa 2d were fed the soiling ration and Lot II., Pearl and Cherry, the silage ration, while the order was reversed in Period II. The rations were carefully weighed for each cow, daily; weekly composite samples taken and the same care in handling and feeding the cows was given as in previous experiments.

Rations Fed.

The silage ration consisted of 40 lbs. of corn silage, daily, fed morning and evening just after milking with a feeding of 4 lbs. of oat and pea hay in order to increase bulkiness and furnish sufficient dry matter. The green forage of the soiling crop ration consisted of three different fodders; millet fodder was fed during the first third, buckwheat fodder during the second third, and corn fodder during the last third of the experiment. The average was 70 lbs. per day. The feed rations of the two experiments were mixed as follows:

Soiling Ration.	*Silage Ration.*
300 Bran.	300 Bran.
100 Gluten Feed.	200 Gluten Feed.
200 Cottonseed Meal.	200 Dried Beet Pulp.
100 Dried Beet Pulp.	100 Cottonseed Meal.

Nine lbs. of each mixture was fed daily to each cow. Table V. gives the food nutrients in the amount consumed by each cow, the soiling ration furnishing about a pound more of digestible matter, but the nutritive ratio of each was about the same. The figures for soiling crops were the averages of the three fodder crops fed.

TABLE V.

SOILING RATION.

Average Daily Ration.	Amount Fed.	Total Dry Matter.	Digestible Nutrients. Protein.	Carbohydrates.	Fat.	Total. (fat x 2¼).
Soiling Crops,	70.00	14.00	.679	7.83	.20	8.959
Wheat Bran,	3.85	3.47	.486	1.61	.11	2.346
Gluten Feed,	1.30	1.19	.289	.69	.03	1.049
Cottonseed Meal,	2.57	2.39	.979	.55	.25	2.089
Dried Beet Pulp,	1.30	1.19	.070	.90	.01	.990
Total,		22.24	2.503	11.58	.60	15.433

Nutritive ratio, 1:5.2.

SILAGE RATION.

Average Daily Ration.	Amount Fed.	Total Dry Matter.	Protein.	Carbohydrates.	Fat.	Total. (fat x 2¼).
Corn Silage,	40.	8.36	.360	4.52	.28	5.510
Oats and Pea Hay,	4.	3.30	.356	1.51	.06	1.996
Wheat Bran,	3.38	3.03	.425	1.40	.09	2.015
Gluten Feed,	2.25	2.09	.557	1.32	.07	2.037
Dried Beet Pulp,	2.25	2.29	.135	1.73	.01	1.885
Cottonseed Meal,	1.12	1.04	.427	0.24	.11	.917
Total,		20.11	2.260	10.72	.62	14.360

Nutritive ratio, 1:5.4.

Yield of Milk and Fat.

Table VI. gives the daily record of the yield of milk and weekly record of the yield of fat. The tests for fat are the results from seven days' composite samples, the sampling being done as in previous experiments. The records of milk run very uniform. The shrinkage of Diana and Princessa 2d from the soiling to the silage ration was 5.6% or what might occur from natural shrinkage due to length of lactation. With Pearl and Cherry the shrinkage from the silage to the soiling averaged 5.2% and may be accounted for naturally as before.

TABLE VI.

Yield of Milk and Fat.

DATE.	LOT I—FIRST PERIOD. SOILING RATION. Diana. Milk.	Diana. Fat.	Diana. Fat.	Princessa II. Milk.	Princessa II. Fat.	Princessa II. Fat.	LOT II—FIRST PERIOD. SILAGE RATION. Pearl. Milk.	Pearl. Fat.	Pearl. Fat.	Cherry. Milk.	Cherry. Fat.	Cherry. Fat.
	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.
August 13,	19.2	.....	.....	27.0	.....	.....	21.7	.....	.....	21.0	.....	.....
" 14,	18.9	.....	.....	25.9	.....	.....	21.5	.....	.....	21.4	.....	.....
" 15,	20.8	.....	.....	26.1	.....	.....	20.7	.....	.....	23.2	.....	.....
" 16,	21.6	.....	.....	27.1	.....	.....	24.1	.....	.....	22.2	.....	.....
" 17,	17.8	.....	.....	24.9	.....	.....	24.9	.....	.....	19.9	.....	.....
" 18,	18.1	.....	.....	25.0	.....	.....	21.3	.....	.....	18.7	.....	.....
" 19,	20.7	.....	.....	28.7	.....	.....	23.5	.....	.....	21.5	.....	.....
" 20,	19.5	4.4	6.89	26.6	3.6	7.61	23.5	3.9	7.07	20.0	3.9	6.55
" 21,	20.9	.....	.....	26.6	.....	.....	23.2	.....	.....	21.8	.....	.....
" 22,	19.7	.....	.....	26.4	.....	.....	21.8	.....	.....	20.7	.....	.....
" 23,	19.0	.....	.....	25.7	.....	.....	22.5	.....	.....	21.1	.....	.....
" 24,	21.7	.....	.....	25.2	.....	.....	23.4	.....	.....	20.8	.....	.....
" 25,	21.2	.....	.....	26.5	.....	.....	23.1	.....	.....	21.8	.....	.....
" 26,	19.7	.....	.....	24.9	.....	.....	22.1	.....	.....	18.0	.....	.....
" 27,	21.6	4.5	6.47	27.1	3.7	6.75	20.0	4.0	6.24	23.1	4.2	6.19
Total,	300.4	.....	13.36	393.7	.....	14.36	337.3	.....	13.31	315.2		12.74
Average,	**20.0**	**4.45**	**.93**	**26.2**	3.65	.96	**22.5**	**3.95**	.89	**21.0**	**4.04**	**.85**
	LOT I—SECOND PERIOD. SILAGE RATION.						LOT II—SECOND PERIOD. SOILING RATION.					
September 2,	21.3	.....	.....	23.5	.....	.....	21.0	.....	.....	21.9	.....	.....
" 3,	19.6	.....	.....	23.2	.....	.....	15.7	.....	.....	21.4	.....	.....
" 4,	18.9	.....	.....	26.1	.....	.....	19.5	.....	.....	21.2	.....	.....
" 5,	19.3	.....	.....	23.6	.....	.....	22.5	.....	.....	20.6	.....	.....
" 6,	19.5	.....	.....	24.1	.....	.....	18.5	.....	.....	21.4	.....	.....
" 7,	19.9	.....	.....	24.5	.....	.....	23.2	.....	.....	19.4	.....	.....
" 8,	16.1	.....	.....	23.1	.....	.....	18.7	.....	.....	21.4	.....	.....
" 9,	18.7	4.3	6.59	23.7	3.7	7.10	22.1	4.3	6.93	17.1	4.5	7.38
" 10,	18.4	.....	.....	24.8	.....	.....	22.8	.....	.....	19.0	.....	.....
" 11,	19.1	.....	.....	27.2	.....	.....	22.5	.....	.....	19.5	.....	.....
" 12,	18.8	.....	.....	26.0	.....	.....	19.1	.....	.....	19.4	.....	.....
" 13,	19.0	.....	.....	26.8	.....	.....	21.8	.....	.....	21.5	.....	.....
" 14,	18.5	.....	.....	25.0	.....	.....	22.1	.....	.....	20.9	.....	.....
" 15,	18.1	.....	.....	25.2	.....	.....	22.1	.....	.....	19.5	.....	.....
" 16,	18.1	4.2	5.46	24.7	3.5	6.29	22.7	4.0	6.12	19.6	4.2	5.86
Total,	288.3	.....	12.05	371.5	.....	13.87	314.8	.....	13.05	303.5	.....	13.24
Average,	**18.9**	**4.25**	**.80**	**24.7**	**3.60**	**.89**	**21.0**	**4.15**	**.87**	**20.2**	**4.36**	**.88**

TABLE VII.

Summary of Experiment.

	SOILING RATION.				SILAGE RATION.			
	Milk.	Fat.	Fat.	Butter.	Milk.	Fat.	Fat.	Butter.
LOT I.	lbs.	%	lbs.	lbs.	lbs.	%	lbs.	lbs.
Diana.	300.4	4.45	13.36	15.59	283.3	4.25	12.05	14.06
Princessa, II,	393.7	3.65	14.36	16.75	371.5	3.60	13.37	15.60
Total,	694.1	4.00	27.72	32.34	654.8	3.88	25.42	29.66
LOT II.								
Pearl,	314.3	4.15	13.05	15.22	337.3	3.95	13.31	15.53
Cherry,	303.5	4.36	13.24	15.45	315.2	4.04	12.74	14.86
Total,	617.8	4.25	26.29	30.67	652.5	3.99	26.05	30.39
Total, Lots I and II,	1311.9		54.01	63.01	1307.3		51.47	60.05
Daily average per cow,	21.9	4.11	.90	1.050	21.8	3.94	.86	1.001

The Summary Table VI. shows that the average daily yield of milk from the two rations was 21.9 lbs. and 21.8 lbs. respectively, or a very slight gain of .5% from the soiling ration. The daily yields of butter were 1.05 lbs. and 1.00 lbs. respectively, or a gain of .05 lbs. or .5% from the same ration. Hence, there was practically no difference in yield of milk and butter from the two rations.

Cost of Milk and Butter.

The cost of producing milk and butter is necessarily greater than usual because of the high prices of feeds. The market quotations being as follows:

Soiling Crops,	$3 50	per ton.
Silage,	4 00	" "
Bran,	28 00	" "
Dried Beet Pulp,	24 00	" "
Cottonseed Meal,	36 00	" "
Gluten Feed,	30 00	" "

The difference between Soiling Crop and Silage represents additional cost of cutting the corn and filling the silo. The average daily ration cost as follows:—Soiling Crop 24.4 cents, Silage ration 24.0 cents. The cost of production for the Soiling Crop ration is, 100 lbs. milk 111.4 cents, 1 qt. of milk, 2.4 cents, 1 lb. of fat, 27.1 cents and 1 lb. butter 23.2 cents. The cost for the Silage ration is, 100 lbs. milk, 110.1 cents, 1 qt. milk 2.36 cents, 1 lb. fat 28.0 and 1 lb. butter 23.97 cents. The gain in milk and butter is only 1.6% for milk and 2.1% for butter from the soiling crop ration.

TABLE VIII.

Yield and Cost of Milk and Butter Produced.

RATIONS FED.	Number Days of Experiment.	Total Digestible Nutrients.	Cost of Daily Ration.	Average Daily Yield Per Cow. Milk.	Fat.	Fat.	Butter.	Cost to Produce. 100-lbs. of Milk.	1 qt. of Milk.	1 lb. of Fat.	1 lb. of Butter.	100 lbs. of Digestible Nutrients Cost.
		lbs.	cts.	lbs.	%	lbs.	lbs.	cts.	cts.	cts.	cts.	cts.
Soiling Crop Ration, ...	30	15.4	24.4	21.9	4.11	.90	1.050	111.4	2.4	27.1	23.2	158.4
Silage Ration, ...	30	14.4	24.0	21.8	3.94	.86	1.001	110.1	2.36	28.0	23.9	166.7

Quality of Milk.

In the Table Summary of Experiment the daily average per cent. of fat in the milk from the Soiling ration was 4.11 and from the Silage ration 3.94, or a difference of only .17%. This is a decrease of less than 4% and probably from conditions which might naturally occur from the same ration. The silage fed was as free from decomposition as winter silage and no injurious effects in respect to flavor of milk could be detected from its use.

Condition of Animals.

There was apparently no difference in the condition of the animals from the two rations and the variation in weight taken at the beginning and end of each period was not enough to draw any conclusion that there was any loss or gain from the respective rations.

Summary of Experiments.

1. There was but 0.1 lb. of milk and 0.05 lb of fat, or 0.5%, respectively, increase from the Soiling crop ration. Hence, in the yield of milk and fat the Silage ration was practically just as efficient.

2. The daily rations cost 24.4 cents and 24.0 cents, respectively, for Soiling crop and Silage. The gain in cost of production was 1.6% from milk and 2.1% from butter on the Soiling crop ration.

3. The quality of the milk did not materially change. There was only an average of .17% of fat difference in favor of the Soiling crop ration.

4. There was apparently no perceptible difference in the appearance of the animals from the two rations. The difference in the weights of the animals did not warrant any conclusion in favor of either ration.

5. The results indicate that corn silage can be fed safely and economically during the summer months.

II. FORAGE CROP EXPERIMENTS.

Soiling Crops, 1907.

The season has on the whole been favorable for the growing of soiling crops, especially the cereal grasses. Rye and wheat wintered remarkably well and although the spring was cold and late these crops continued to make good growth and the rye was ready for feeding on the 11th day of May, about ten days later than last season. Because of the lateness of the spring it was

impossible to get early soiling corn planted at the usual time, our first planting being May 15th and while this corn was slow in germinating the growth was very satisfactory and the yield quite up to the average. Alfalfa has given very satisfactory yields, while growth was hindered by the cold spring, three or four cuttings have been taken this season. Cow peas and Soy beans have not done nearly as well as usual. Our first planting was June 26th, almost three weeks later than usual. Late planted cow peas yielded a little over one-half as much green fodder as last season and very few pods were formed. Barnyard Millet, which yielded 10 to 15 tons per acre last season, gave between 8 and 9 tons on very similar conditions of soil and manuring. Peas and Oats gave extremely good yields on medium heavy soils, the average yield being greater than last season. Late fodder corn was very poor where planted after rye, wheat or peas and oats. Where the land was plowed before replanting to corn and not well compacted the dry weather penetrated the soil so as to check the growth of the crop, maturing but few ears and producing a light yield. Crimson clover was a little below an average crop, the smaller yield not being due to poor wintering but more largely to a poor stand from the previous fall seeding. On the whole the dry weather did not so seriously affect the crops in this vicinity as it did in districts west and north. The cold and backward spring on our heavy soils was a very serious handicap for corn and cow peas, but did not seem to affect the grass crop, in fact, larger yields of hay have been harvested this season than for several seasons previous. Our usual rotation system has been followed, beginning on the 11th of May with rye followed by wheat, mixed grasses, alfalfa, peas and oats, barnyard millet, buckwheat, cow peas and corn fodder in rotation as named, with the exception of August and part of September, when corn silage was wholly substituted for three weeks and partially substituted for another period of from two to three weeks. This was done as an experiment to see if silage could be substituted economically and produce a satisfactory quality of milk at this season of the year.

TABLE IX.

Acreage, Date of Planting and Cutting and Yield of Soiling Crops.

KIND.	Acreage.	Seed Used per Acre.	Date of Seeding.	Period of Cutting and Feeding.	Plot Number.	Number of Days Between Planting and Cutting.	Total Yield.	Yield per Acre.
		bu.						
Rye,	1	2	Sept. 26,	May 11–15,	C	......	6.4	6.4
Rye,	1	2	" "	" 16–19,	D	......	6.4	6.4
Rye,	½	2	" 29,	" 20–21,	E	......	3.4	6.8
Rye,	½	2	" "	" 22–23.	G	......	3.6	7.2
Rye,	1	2	Oct. 10,	" 24–28,	26	......	6.7	6.7
Wheat,	1	2	Sept. 20,	" 28–June 2,	M	......	7.5	7.5
Grass,	......	......	......	June 3–7,	Lawns	......	6.8	......
Wheat,	1	2	Sept. 25,	" 8–10,	O	......	5.8	5.8
Wheat,	1	2	Oct. 10,	" 11–18,	25	......	11.1	11.1
Alfalfa, 1st cutting,	2	30 lbs.	Aug. 30,	" 19–24,	16 and 17	......	10.6	5.3
Oats and Peas,	2	1¾–1⅓	March 28,	" 25–July 5,	20 and 21	89	20.2	10.1
Oats and Peas,	2	2–1½	April 4,	July 6– " 14,	18 and 19	93	15.3	7.7
Oats and Peas,	2	2–1⅓	May 1,	" 15– " 23,	Triangle	76	17.7	8.9
Silage,	......	......	......	" 24–Aug. 6,	......	......	12.0	......
Millet (Barnyard), with Silage,	1	¾	June 7,	Aug. 7– " 15,	26	61	8.3	8.3
Buckwheat, with Silage,	1.8	1⅓	July 8,	" 16– " 26,	27 and 28	39	11.3	6.3
Cowpeas, with Silage,	1	1½	June 26,	" 27–Sept. 2,	25	62	9.7	9.7
Grass, 2d crop,	4	......	......	Sept. 3– " 10,	1–4	......	10.4	2.6
White Flint Corn Fodder,	1	⅓	May 15,	" 11– " 19,	A	119	12.6	12.6
Cow Peas,	2	1⅓	July 26,	" 20– " 24,	P and Q	56	8.6	4.3
Corn Fodder (from Silage Corn Field),	⅜	......	May 24,	" 25– " 27,	R. S. T.	93	4.0	10.6
Cow Peas,	⅓	1½	July 31,	" 28– " 29,	23	59	2.1	6.3
Alfalfa, 4th cutting,	2	......	Aug. 22, '06,	" 30–Oct. 3,	29	......	6.6	3.3
Cow Peas,	1⅛	1½	July 25,	Oct. 4– " 8,	18 and 19	70	6.0	5.3
Corn Fodder,	5	⅓	Aug. 1,	" 19– " 18,	New Field	80	15.7	3.1
Grass, 2d crop,	4	......	......	" 19– " 23,	A part of 5 to 15	......	4.1	1.0
*Total,	......	......	......	......	......	......	232.9	......
Average yield per acre, excluding grass,	......	......	......	......	......	......	......	7.15

* Supplying forage to 38 adult and 12 young animals, including silage.

Table IX. gives the acreage, date of planting and yield of soiling crops beginning May 11th and ending October 23d. A period of 166 days with a total of 232.9 tons of green fodder, or an average of 7.15 tons per acre. This supplied forage for 38 adult and 12 young animals. The corn fodder was partly fed in the stables and partly fed in the exercise yards. In portions of the summer, when favorable, all feeding was done in the yard, with the exception of grain feed. This was fed on an average of 6 to 8 lbs. per day. When the soiling crop was largely nitrogenous in character, as for example, early rye, alfalfa and cow peas, the feed ration consisted of a large portion of starchy feeds and was furnished in the form of hominy, corn meal and beet pulp.

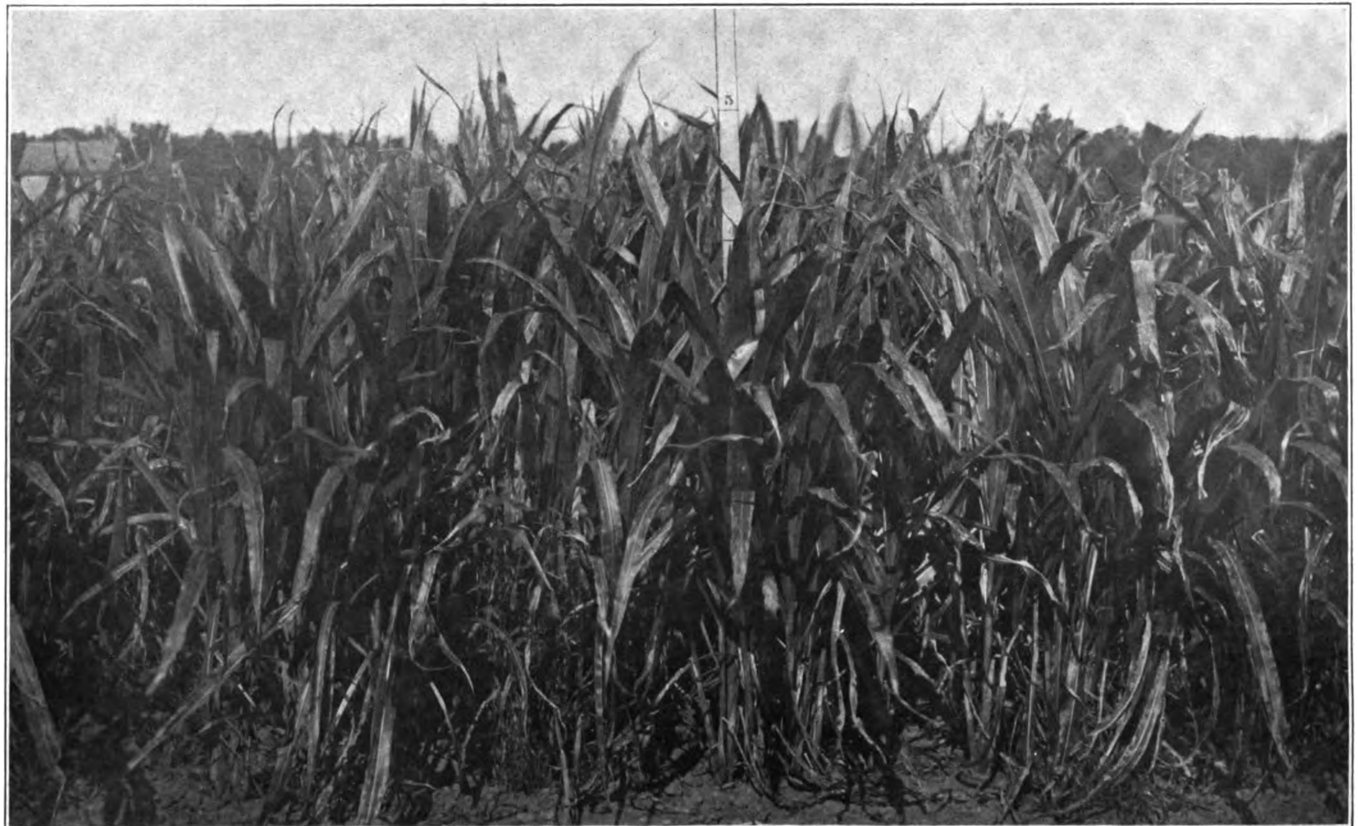
TABLE X.

Cost and Total Nutrients in Fodders.

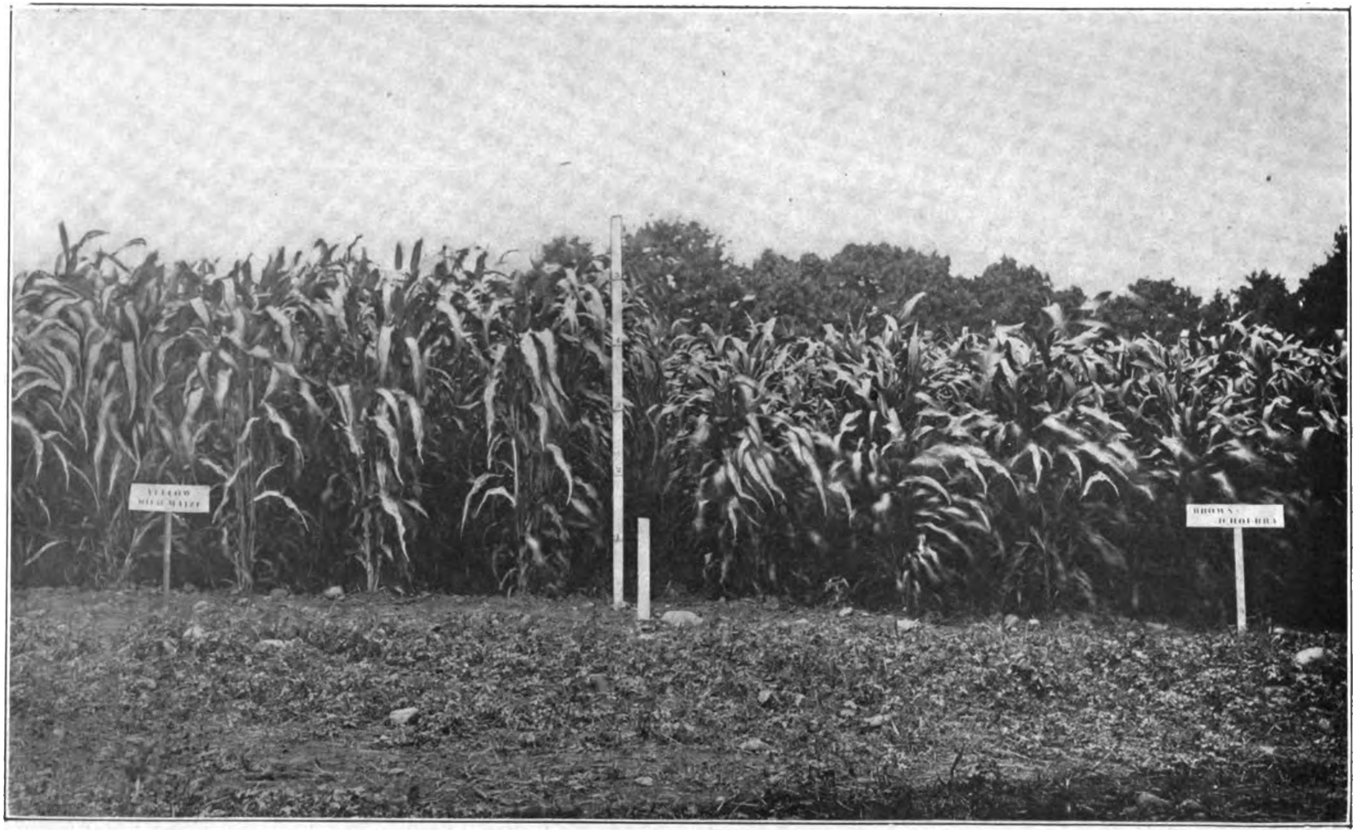
KIND.	Tons Fed.	Cost.					Total Nutrients.		
		Seed.	Manure and Fertilizers.	Labor.	Total.	Average per Ton.	Protein.	Fat.	Carbohydrates.
Rye, ...	26.5	$5.20	$14.00	$9.90	$29.10	$1.10	1007	265	11236
Wheat, ...	24.4	6.00	13.87	10.80	30.67	1.25	1171	342	8686
Grass, ...	6.8	....	....	8.00	8.00	1.17	340	68	1887
Alfalfa, 1st Cutting, ...	17.2	....	6.39	7.87	14.26	.83	1548	310	5985
Oats and Peas, ...	53.2	18.12	25.77	21.35	65.24	1.23	3085	638	15747
Jap. Barnyard Millet,....	8.3	1.83	11.99	4.25	18.12	2.18	249	100	2424
Jap. Buckwheat, ...	11.3	2.50	12.90	8.80	24.20	2.13	299	69	4407
Cow Peas, ...	26.4	19.80	32.78	16.20	68.78	2.60	1636	369	6356
Grass, 2d Cutting, ...	14.5	....	5.00	6.00	11.00	.76	812	203	4727
Corn Fodder, ...	16.6	1.06	18.10	8.22	27.38	1.65	896	266	6275
Corn Fodder, not Mature,	15.7	5.25	....	20.00	25.25	1.60	565	157	5401
Total, ...	220.9	$59.81	$140.80	$121.39	$322.00	*$1.46	11608	2787	72631

* $1.46 represents the cost per ton in the field. The average cost for cutting and hauling is about 50 cents per ton, or $1.96 is the cost per ton at the feeding yard.

	Protein. lbs.	Fat. lbs.	Carbohydrate. lbs.
4 tons clover hay furnish........................	948	184	5648
2 " " " "	492	492	2824
1 " " " "	246	46	1412
1 " alfalfa " "	330	54	1286
3 " wheat bran "	960	276	3732
3 " corn meal "	540	246	4363



Teosinte just before cutting. Soiling Crop Experiment.



Yellow Milo Maize. Brown Durra.

Soiling Crop Experiment.

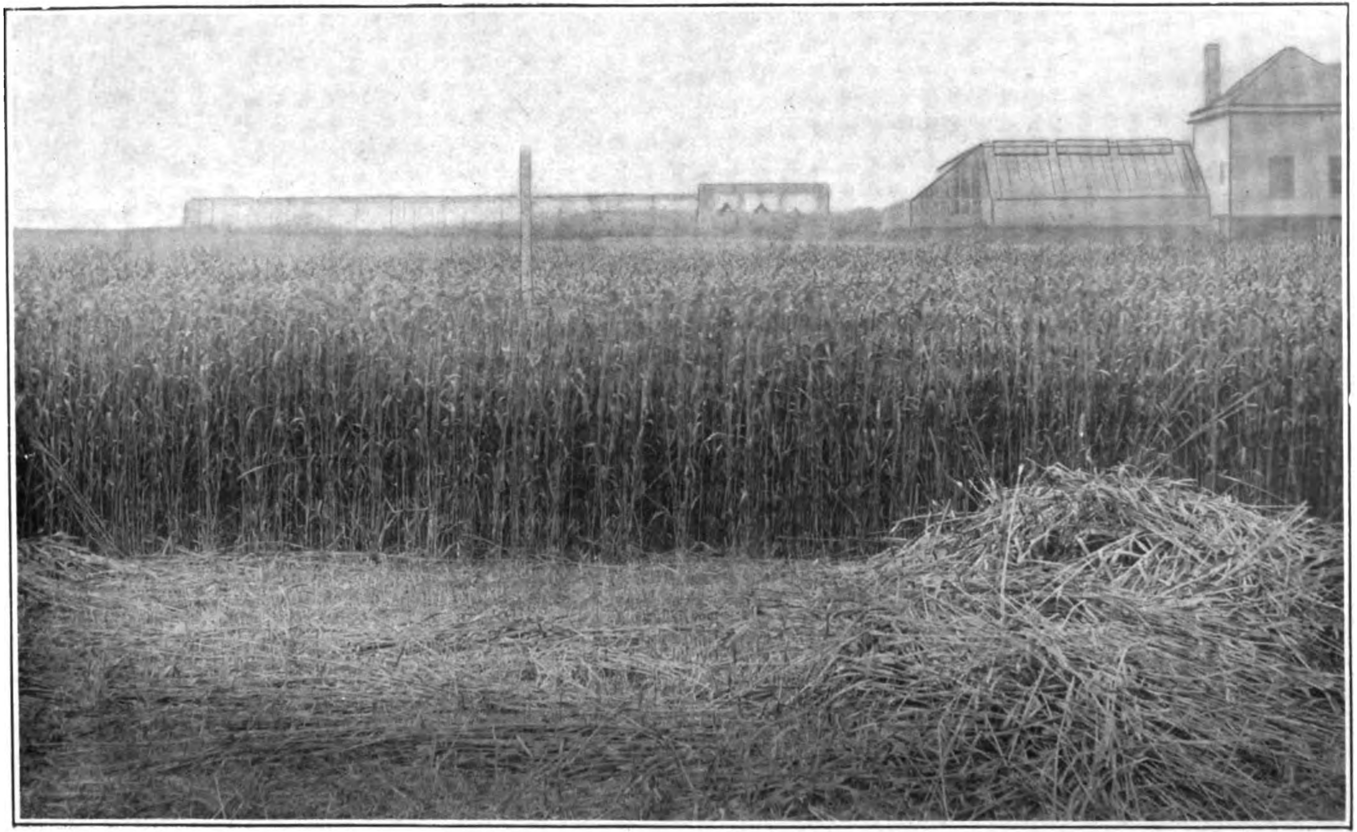
The cost of growing soiling crops is tabulated in Table X., giving the amount fed, the cost of seed, manures and fertilizers, labor and the average cost per ton. This report does not include the cost of cutting and hauling to the feeding yard. Team and man was charged at the rate of $4.00 per day, which, according to present conditions is as low as any farmer can afford to fix for his labor and team work. Manure was valued at $1.50 per ton and the cost of fertilizers at the retail price for this season. Cow pea seed was unusually high, making the cost of that crop considerable. The average cost per ton averages 76c. and 83c. respectively for second cutting grass and alfalfa, about $2.60 per ton for cow peas, or an average for all of the soiling crops of $1.46 per ton for the year. Allowing 50c. per ton for cutting and hauling, which is a minimum cost, it would make the average $1.96 per ton as fed to the animals. Table X. also gives the total nutrients in the different fodders consumed. Comparing these figures with the total nutrients in clover hay, alfalfa, bran and corn meal we find that rye or wheat furnished as much protein as that contained in 4 tons of clover hay, or 3 tons of wheat bran. Fifty-three tons of oats and peas furnished as much food nutrients as that contained in 13 tons of clover hay or a little over 9 tons of wheat bran. The total nutrients in 232.9 tons of soiling crops on this basis will furnish about the same amount of food nutrients as that contained in 49 tons of clover hay or 36 tons of bran.

Rye.—This crop is one of the earliest which we can use for soiling and generally in this region is ready for cutting about the first day of May. For soiling purposes it is much better to make several plantings of the rye, the first early in September or possibly in August, sowing it between the rows of corn. The last planting may be put in October 15th or sometime later according to the season. This rye was planted by simply cutting the corn stubble with a disk harrow, following with a smoothing harrow and putting in the seed with a drill. There was very little difference in the yield of the early and late planted rye. The feeding period was short since it was held back by the cold spring and after it attained its growth it matured very rapidly, the stalk hardened and the feeding of it had to be stopped.

Wheat.—The first planting was made September 20th and the last planting as late as October 10th. These fields had no application of fertilizers at the time of planting, but the field which was last planted had an application of manure in the early summer, followed by a crop of cow peas. The influence of this treatment was very marked, the yield of wheat fodder being 11.1 tons per acre as compared with about 6 tons per acre from the early planted field, which also had an application of manure for the previous crop. The quality of forage was very good, although the period of feeding was shortened by the late season. Wheat fodder is very palatable, holds its succulence longer than rye and is very satisfactory as a soiling crop.

Alfalfa.—Only a portion of the alfalfa grown on the College Farm this year was fed in a green state, since it has been the object of the farm to grow as much as possible for hay in order to help reduce the amount of purchased feeds consumed in the winter ration. Only the first cutting from a newly seeded field was fed green. The yield was not heavy as the stand was not even. Some portions of the field had been re-seeded in the early spring. Alfalfa, however, is quite nitrogenous in character, makes an excellent soiling crop and three to four cuttings can usually be taken in a season. The early summer was very favorable for the growing of alfalfa, although cool there was sufficient moisture so that a large growth was made in May, July and August. Further notes on this crop, in respect to growing it for hay, will be found under the subject "Field Crops."

Oats and Peas.—Six acres were devoted to this crop. The first planting was made the 28th day of March; second April 4th and the third May 1st. This latter date is about as late as we can sow Canada peas in this region, since the warm weather frequently checks the growth and the field louse often is troublesome. Three varieties of oats were planted for comparative tests. The first planting was seeded with Ninety-day Burt, the second with the Swedish, the third with the ordinary White Spring variety. The Swedish variety was very leafy with a broad leaf blade but seemed to be later than the White Spring. The quality of fodder was very good. All the varieties lodged and in places were so badly down that considerable forage was lost in har-



Wheat. 11.1 tons of green forage per acre.

Peas and Oats badly lodged, showing effect of season.

vesting. There was a large proportion of pea vine in the fodder. The Burt was very satisfactory as an oat for early forage. The first planting gave a yield of 10.1 tons per acre, the second 7.7 tons and the third variety 8.9 tons. The increase of yield, however, from the Burt variety was probably largely due to an application of lime, which was made the previous fall. The variety of Canada peas used this season was the Golden-vine. This crop is very valuable for soiling since it can follow in rotation, wheat, alfalfa and crimson clover and gives a succulent nutritious feed greatly relished by animals and can generally be depended upon for feed beginning the first week in June and continuing as late as the first week in July. May 1st is as late as Canada peas can be planted here with any certainty of a crop. For later planting, spring vetch with oats would give better results and can be used for feed as late as July 15th.

Millet.—Barnyard Millet usually follows oats and peas and under favorable conditions this crop will mature in forty-five or fifty days after planting. Its chief value as a forage crop is its advantage in short rotations and large yield of green fodder. If cut before the heads are fully formed the forage is more palatable and nutritious but soon after this stage, the stalk rapidly hardens. The plant contains a large per cent. of water, hence, larger feedings are necessary to get the same amount of dry matter.

Kafir Corn and Cow Peas; Milo Maize and Cow Peas.—Kafir corn and milo maize belong to the same class of cereals and closely alike in habit of growth. Both mature about the same as the cow pea and therefore can be grown together making in itself almost a balanced ration for milch cows. The milo maize has a larger stalk, taller and more succulent. Both are very palatable when cut at the time the heads appear, giving large yields of forage, which can be put into the silo if needed. It can be planted any time between June 1st and August 1st. It will do best on medium moist lands well supplied with organic matter and, therefore, should follow a crop of crimson clover, Canada peas and oats or cow peas. It does better in a hot, moist season, hence this season was not favorable and where 12 and 14 tons per acre has been the maximum yield only about 6 tons per acre was harvested this season.

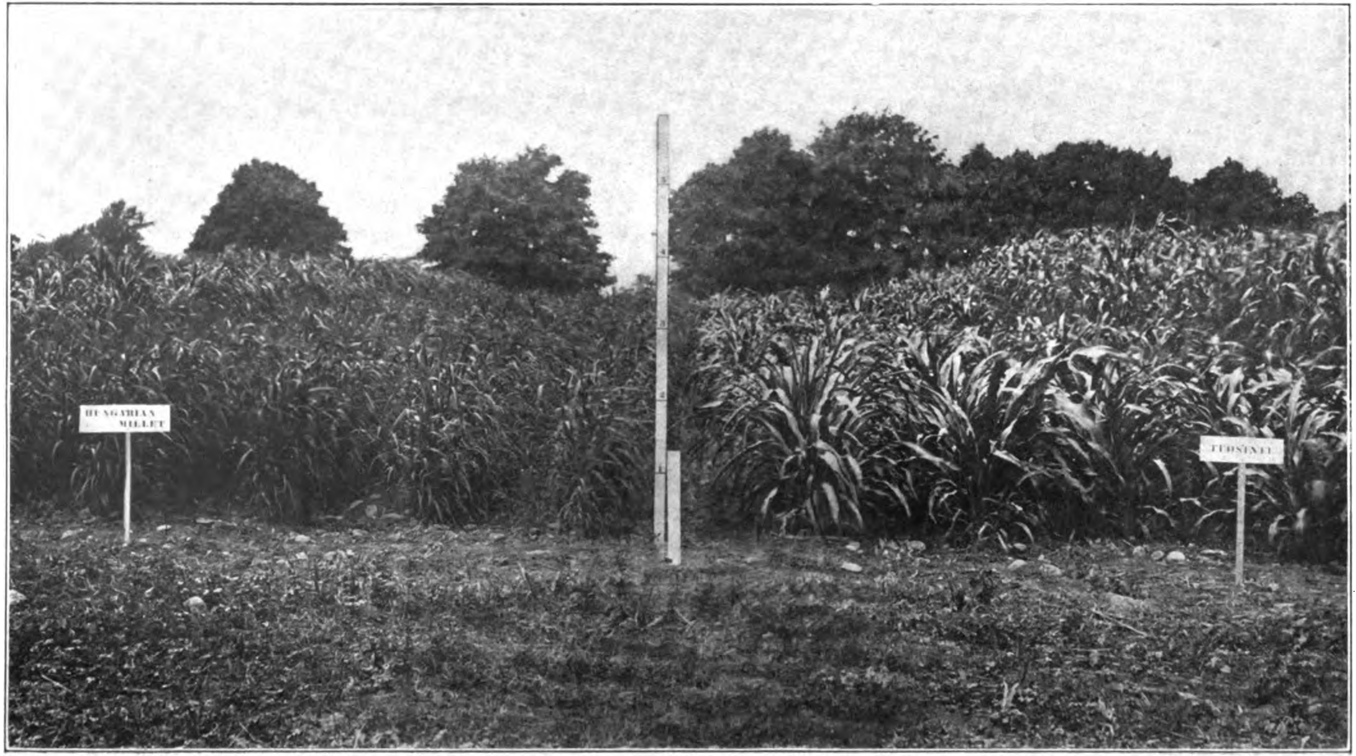
Buckwheat.—As an experiment 1¾ acres of Japanese Buckwheat was sown July 8th, following crimson clover, for soiling. About 140 pounds of commercial fertilizer was applied and 1¼ bushels of seed per acre was drilled. The stand was good. Because of the nature of flowering the plant remains in bloom a long time. Cutting was begun as the lower flowers began to mature seed and while the stalk was quite succulent. The yield was 11.3 tons or about 6.5 tons per acre. At first the cattle did not relish it, but after a few feedings they took their full ration. After the later blossoms began to mature seed, the stem rapidly became woody and the plant lost its value as a forage. It matures quickly and is therefore valuable in short rotations. By planting from the 15th to the 30th of June, cutting may begin forty days later or just before corn is ready. It may be possible to plant it still earlier so as to allow cutting to follow that of oats and peas.

Cow Peas.—The season was rather unfavorable for a large yield of forage. The plant requires hot, humid weather for best developments. The dry cool weather in August checked the growth, it matured but few blossoms and practically no pods. The yield averaged fully 9.7 tons from an early planted plot, but only from four to six tons where planted August 1st. A portion of the crop was put into the silo.

The influence of cow peas in improving the mechanical conditions of the soil and increasing its nitrogen content was shown by the increased yield of wheat fodder from a field which previously had been planted to cow peas. No manure or fertilizer was applied at the time of planting the wheat and the yield of green fodder was 11.1 tons per acre as compared with six to eight tons from a field which had similar fertilizer treatment, but grown after corn. The soil from the latter field, however, was of a heavier character.

Thoroughbred White Flint Corn.—The spring was very backward and our first planting could not be made until May 15th. Immediately after planting came a cold, beating storm and the ground was packed so hard that germination seemed impossible, however, by repeated weeding and harrowing the crust was broken and from 80% to 90% of the seed germinated. The

Burt 90-day Oat and Golden Vine Canada Peas. Yield, 10.4 tons of green forage per acre.



Hungarian Grass. Soiling Crop Experiment. Teosinte.

growth at first was very slow, but the young plants got well established to take advantage of the warm weather later, and the final growth was excellent; 12.6 tons of green fodder being taken from an acre with a large proportion of mature ears.

Later plantings in June after a cutting of rye produced but little more than a half of a crop. The rye stubble was turned over with a plow and although the soil was firmed with a roller, it is probable that the influence of the dry weather in July penetrated to a greater depth and checked the supply of soil moisture. Preparation of the soil by harrowing instead of plowing would prevent this trouble, and the method should be followed whenever possible during hot weather.

Soiling Crop Rotations.

Because of the late spring, it was impossible to harvest three crops from any field. Rye and wheat was cut nearly two weeks later than usual and the growth of the succeeding crops of millet or cow peas was slow, so that the cutting of these was made too late for the planting of a third crop. In one case, barley and peas was planted August 20th, but not over ten inches growth was made when freezing weather came and this was left as a cover crop to prevent winter washing. Cow peas have been followed by winter rye or wheat which will be used for early soiling or green manure as conditions require next season. Again, several fields were not devoted strictly to soiling rotations, as for example; peas and oats made into hay, followed by cow peas used for soiling, then seeded to rye or wheat. Crimson clover made into hay, followed by buckwheat used for soiling, then seeded to timothy and clover. One acre plot (25) yielded 11.1 tons of wheat and 9.7 tons of cow peas or a total of 20.7 tons. This field was seeded early in September to rye. Plot 26 yielded 6.7 tons of rye fodder and 8.3 tons of millet or a total of 15.0 tons of soiling crops. This field was the one planted to barley and peas. Plots M and N had wheat, followed by corn, giving a total yield of 13.6 tons per acre.

Experiments with Soiling Crops, 1906.

One acre was devoted to small plot experiments with soiling crops. It included nine varieties of cow peas, one variety of Soy beans, Sorghum, Sorghum and cow-peas, Kafir corn and cow peas, Barnyard Millet, German Millet, Pearl Millet, Hungarian Millet, Teosinte, Yellow Milo Maize and Brown Durra.

Plan of Soiling Crop Experiment.

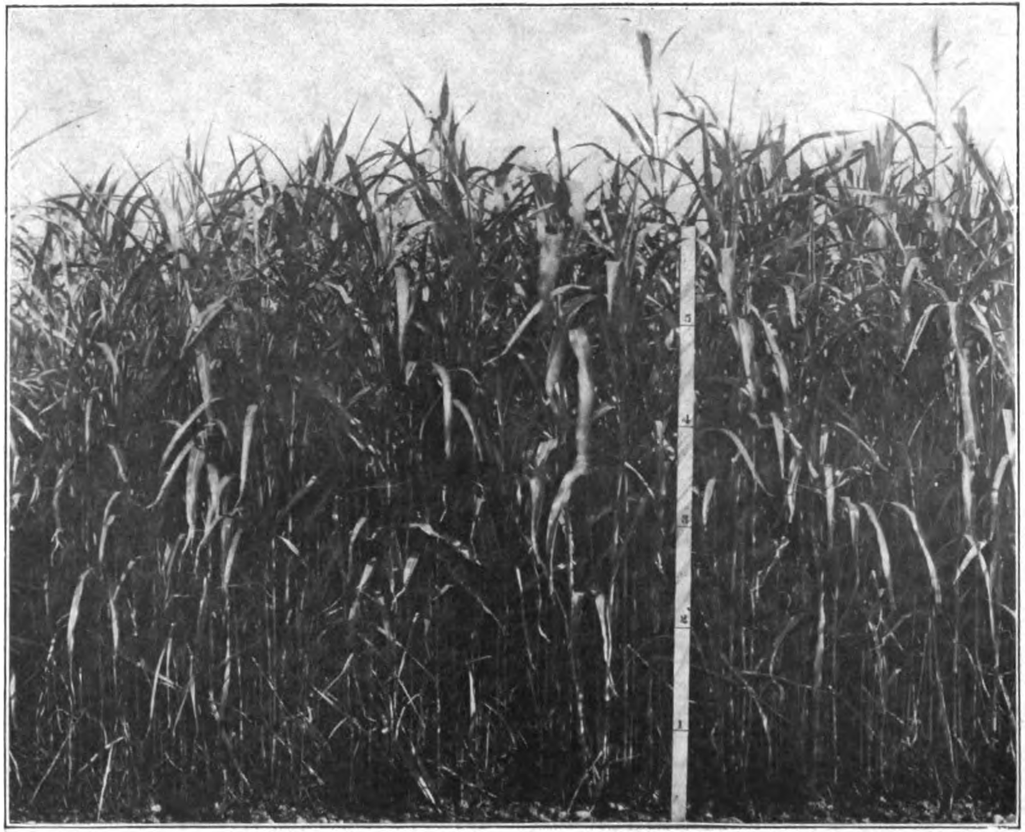
Hollybrook Soy Bean.	Brown Durra.
Extra Early Blackeye Cow Pea.	Yellow Milo Maize.
Rice Cow Pea.	Teosinte.
Red Carolina Cow Pea.	Hungarian Millet.
Iron Cow Pea.	Pearl Millet.
Michigan Favorite Cow Pea.	German Millet.
Southdown Cow Pea.	Barnyard Millet.
Gallivant Cow Pea.	Kafir Corn and Cow Peas.
Whippoorwill Cow Pea.	Sorghum and Cow Peas.
Red Ripper Cow Pea.	Sorghum.

Soiling Crop Plots.

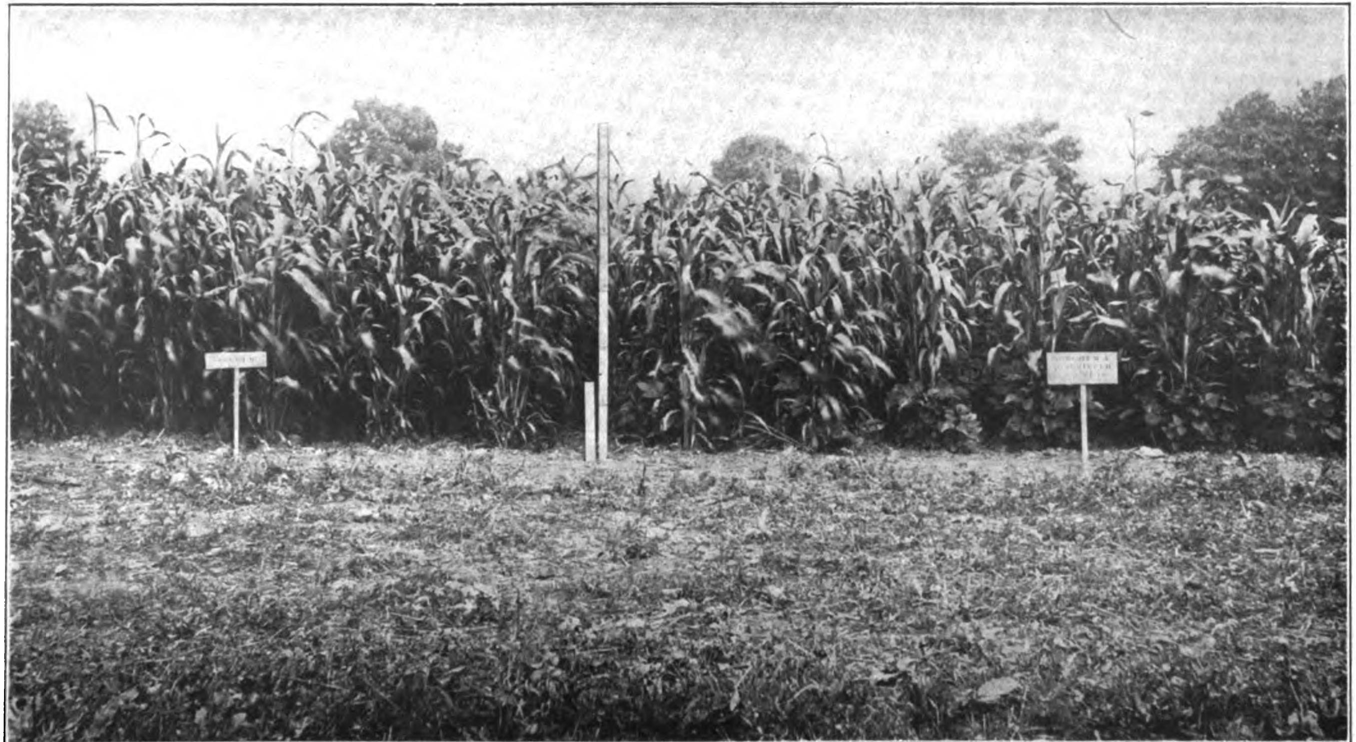
Each plot contained 1-20 of an acre in area. All of the crops were planted in drills 2¼ ft. apart and cultivated. The cow pea plots were planted June 16th and the sorghum, millets and other cereal plots June 21st.

General Remarks Concerning Crops.

Sorghum.—In habit of growth it is very much like Kafir corn, but more corn like in appearance; the grain is borne in the tassel and not in ears. It germinates readily but makes a slow early



Sorghum just before cutting. Soiling Crop Experiment.



Sorghum. Sorghum and Red Ripper Cowpeas.

Soiling Crop Experiments,

growth and should be sown in thick drills, but may be broadcasted if the land is free from weeds. The field should be well manured, particularly with phosphoric acid and potash. Cutting should begin as the heads appear, where the object is for soiling. If cut and fed when the plant reaches a height of five or six feet, a second crop may be secured. Sorghum is very succulent and therefore low in dry matter. It can be used for silage. The heads appeared seventy days after planting, and cut ten days later, yielding at the rate of 17.2 tons per acre. Plant 10 qts. per acre if in drills or 3 pecks if broadcasted.

Sorghum and Cow Peas.—This combination is very satisfactory, since both plants mature at the same length of time after planting. The cow peas will increase the palatability and protein content of the food. The variety of cow peas grown was the Red Ripper, which grew to a height of 3 feet. The yield was at the rate of 14.4 tons per acre. Plant 1 bushel of cow peas and 3 pecks of sorghum when sown broadcast.

Kafir Corn and Cow Peas.—Kafir corn does not grow nearly as tall as sorghum, but is leafy, palatable and will yield under favorable conditions 13 tons per acre. It appeared in head a little later than the sorghum and produced a yield equivalent to 10.5 tons per acre. The rate of seeding can be the same as for sorghum and cow peas.

Barnyard Millet.—One of the best varieties of millets for soiling, producing tremendous yields when the soil and moisture conditions are favorable. It should be borne in mind that it is an exhaustive crop when ten to fourteen tons of green forage can be grown in forty-five to fifty days, and the soil should receive liberal manuring. The yield on this plot, 8.9 tons, was much below the yield of millet grown on another field following alfalfa. This field produced a growth of 14.3 tons of green fodder per acre. Sow 3 pecks per acre, if applied broadcast.

Foxtail Millets., include German and Hungarian Millet or Hungarian grass. The latter grows quickly and may supplement the regular hay crop. The yield is not nearly as great as the barnyard variety, but the hay is of better quality. The yield on this plot was only 3 tons of green forage. The German millet

is leafy with heads bearing considerable seed. The stems have a tendency to be woody unless cut early. The yield was 5.5 tons per acre.

Pearl Millet, or Cat-tail Millet, will make large yields on rich lands, well manured, under favorable conditions. It is a summer plant. In the plot experiment the growth was slow with a tendency to woody stems and but few stalks had tasseled at cutting, over three months from seeding. The yield was 12 tons per acre. Because of the length of time it takes to mature, Barnyard Millet is to be preferred for soiling.

Teosinte.—Very similar to millet in habit, with great tendency to stool. It is slow maturing in this region, no tassels being formed, very leafy with low dry matter content which is only one-half that of corn. Yield 9 tons per acre.

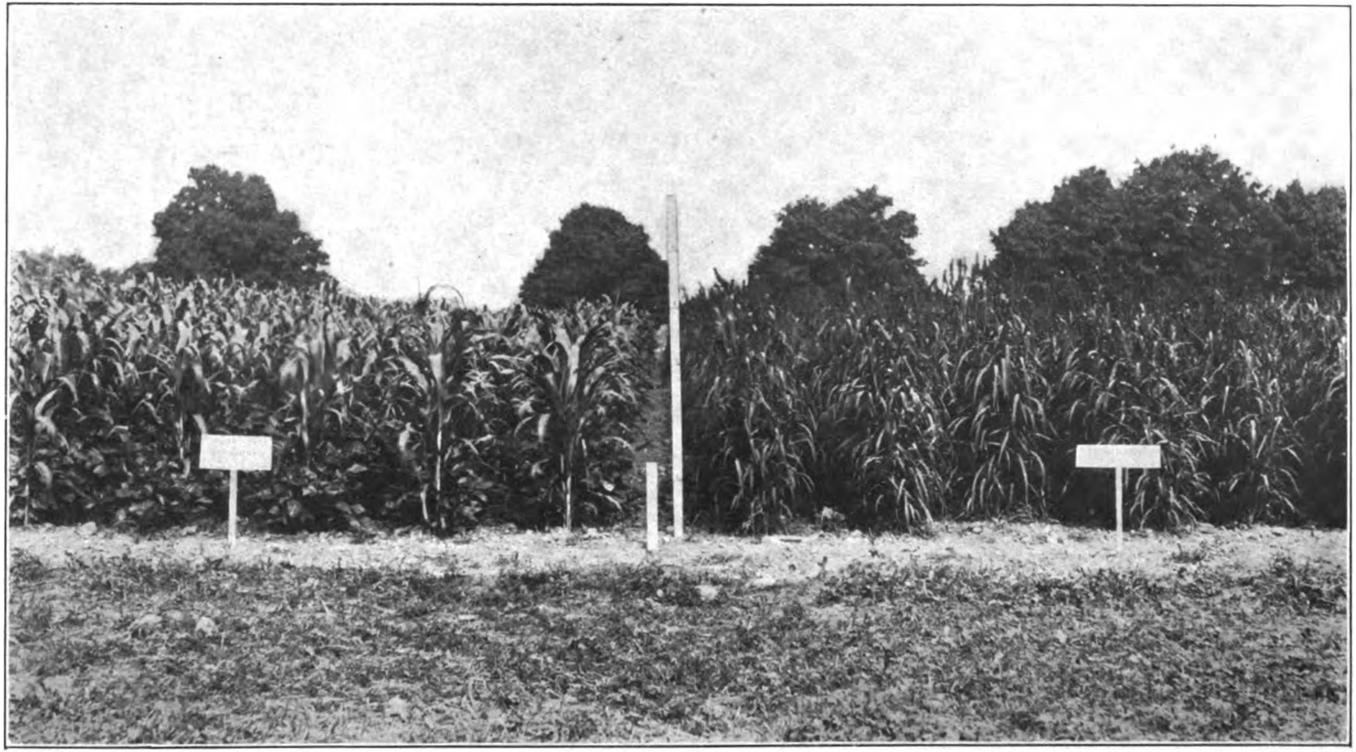
Yellow Milo Maize.—This plant belongs to the same family as Kafir corn and closely resembles it. It is taller, more vigorous in growth, with larger stems, but succulent and makes a taller growth than the Kafir varieties. Yield, 12.4 tons of green forage per acre. It matures for soiling about the same time as sorghum. In combination with cow peas it is very valuable for soiling. The rate of seeding is the same as for Kafir corn.

Brown Durra.—Very much like milo maize, but slower maturing and less desirable. Yield, 10.2 tons per acre.

Cow Peas.

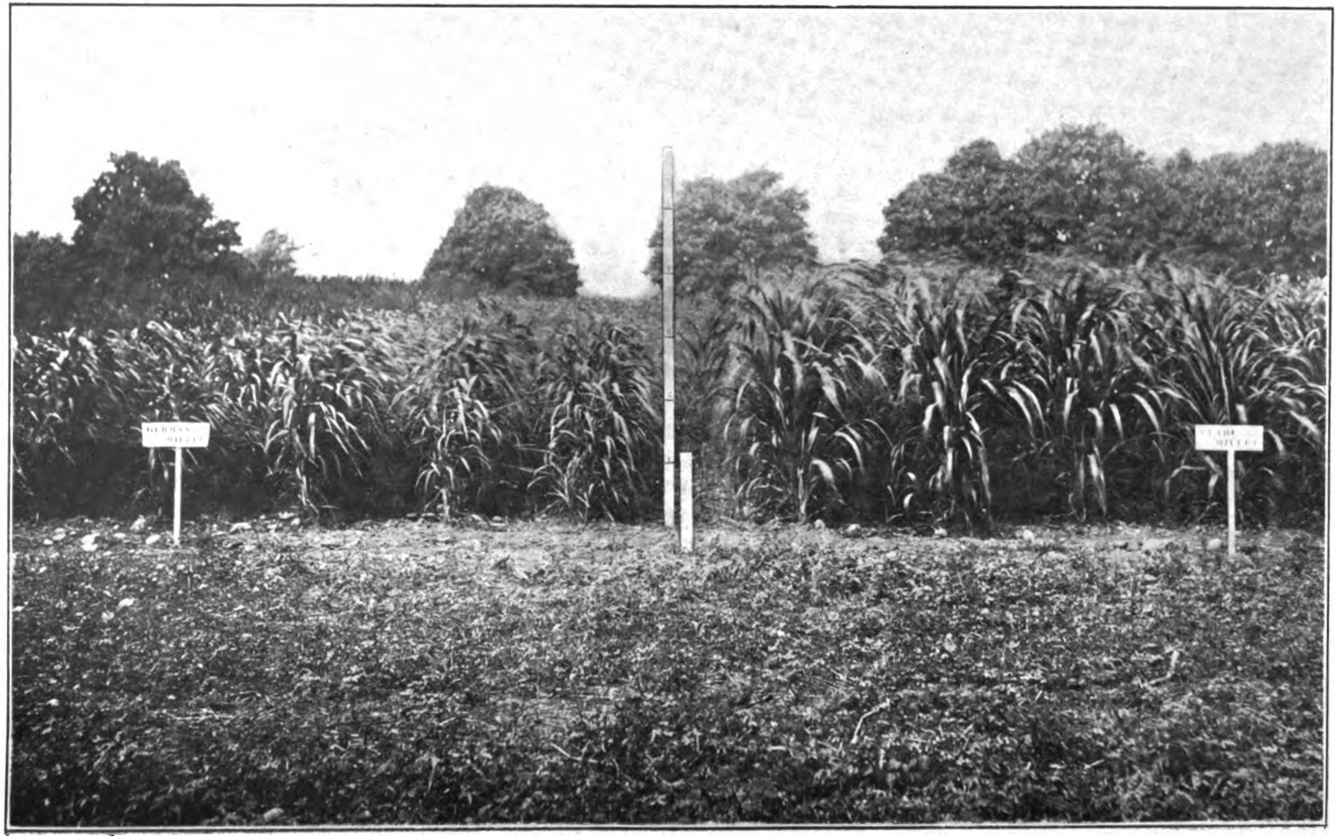
One end in view in the test with cow-peas was to secure record of the yield of seed. This season was not as favorable as the summer of 1905, when results with a plot test of seven varieties were reported. In some cases the pods were but half filled and when threshed contained immature seeds. Brief field notes concerning each variety are as follows:

Red Ripper.—Medium late, very heavy growth, plants 2-3 feet tall with vines 1-2 feet. Habit, erect. Begun to blossom in 74 days, pods in 81 days, mature pods in 102 days. Yield, 7.8 tons of forage and 8 bushels seed per acre. Very desirable for soiling or for hay.



Kafir Corn and Red Ripper Cowpea. Jap. Barnyard Millet.

Soiling Crop Experiment.



German Millet. Pearl Millet.

Soiling Crop Experiment.

Whippoorwill.—Medium late, vigorous, plants 2½ feet high with vines 2-3 feet. Vines tangled, trailing, matures in about the same time as the Red Ripper. Yield, 7.8 tons of green forage and 14 bushels of seed per acre.

Gallivant.—Medium in maturing, 2½ feet high, vines 1-2 feet erect. Blossoming in 64 days. Yield, 7 tons per acre of green forage and 16 bushels seed per acre. Well podded, with small white seeds.

Southdown.—Variety not vigorous, with considerable leaf blight, trailing with vines 3 to 5 feet. Yield, 7.2 tons of green forage and 2½ bushels seed per acre.

Michigan Favorite.—Seed germinated poorly, low, trailing; pods heavy and large; more suitable for seed than for forage. Medium early in maturing. Yield, 6.5 tons green forage and 18 bushels seed per acre.

Iron.—Very vigorous, said to be fungus proof; 2½ feet tall, medium trailing vines 2 feet. Medium in maturing. Stems heavy and succulent, trailing, excellent for green forage. Yield, 8.6 tons green forage and 10 bushels seed per acre.

Red Carolina.—Very much like the Red Ripper, but more trailing. More adapted for seed. Yield, 5.7 tons of green forage and 13 bushels seed per acre.

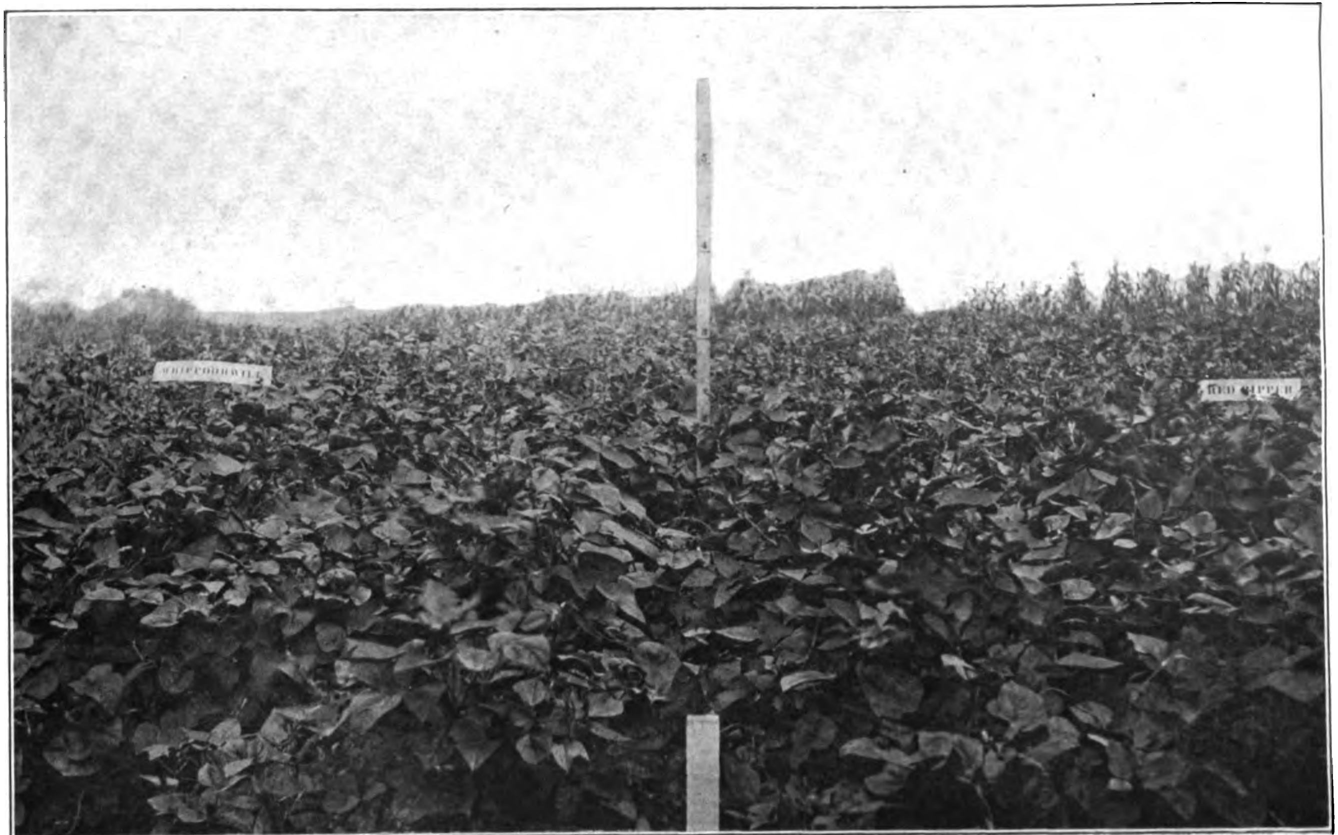
Rice.—Seed small and white and used on the table in the South. Vigorous, but not as rank growing as the Red Ripper, Whippoorwill or Iron. Yield, 6.9 tons of green forage and 3 bushels seed per acre.

Extra Early Blackeye.—Not adapted for forage, trailing, not succulent. Seed mature in 80 days. Yield, 6 tons of green forage and 11 bushels seed per acre.

Hollybrook Soy Bean.—Very thrifty, 3½ feet tall, podded September 4th, mature October 1st. Yield of green forage, 5.4 tons and 16 bushels seed per acre.

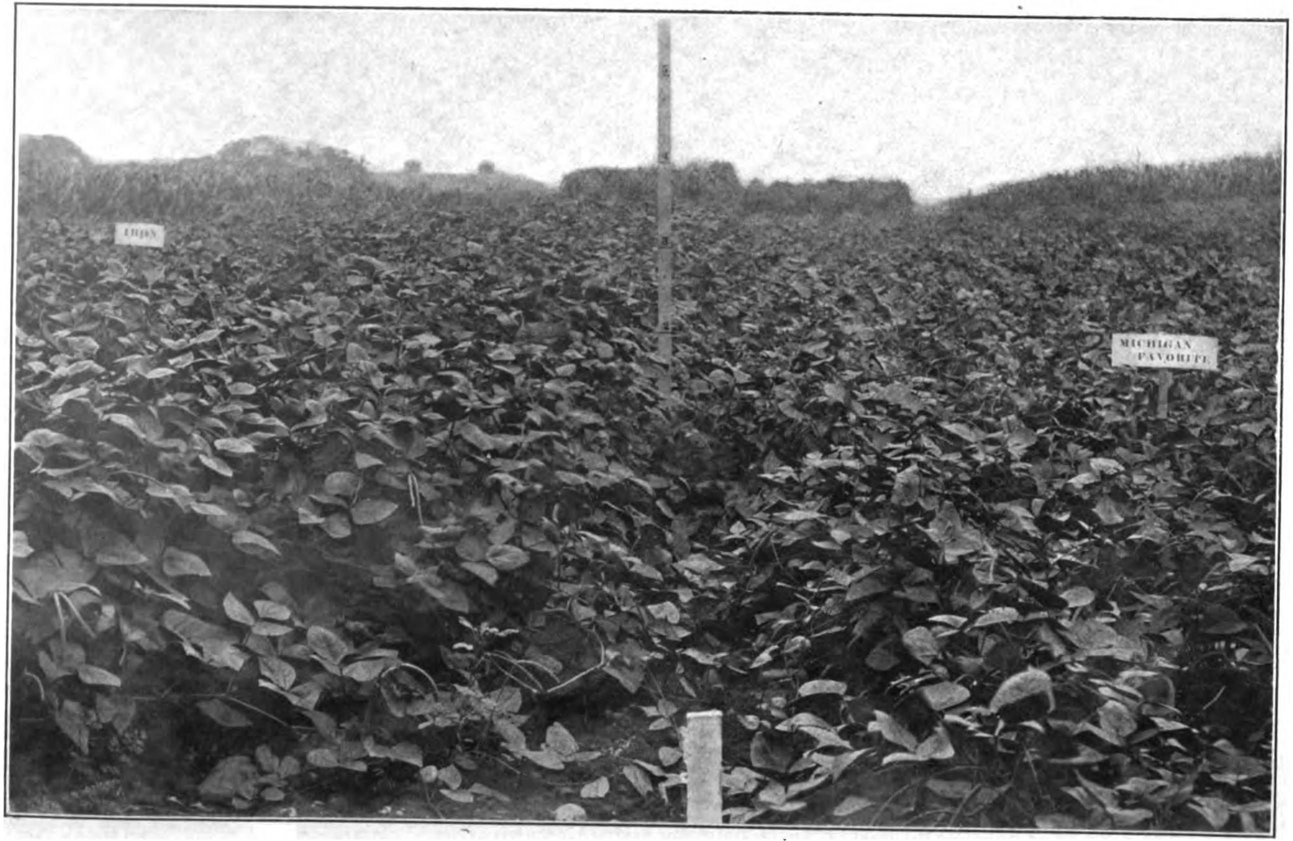
TABLE XI.

VARIETY.	Area.	CHARACTER.	Maturity.	Yield of Green Forage Per Acre. Tons.	Yield of Seed Per Acre. Bu.
Red Ripper, ...	1-20	Erect, vines 1-2 ft., heavy stem, succulent,..............	Late, ...	8.5	8.
Whippoorwill, ...	"	Beginning to trail, vines 2-3 ft., thrifty,..................	Late, ...	7.3	14.
Gallivant, ...	"	Erect, vines 1-2 ft., thrifty, well podded,.................	Medium, ...	7.0	16.
Southdown, ...	"	Trailing, vines 2-3 ft., affected by leaf blight,............	Medium, ...	7.2	2½
Michigan Favorite,..............	"	Trailing, heavy stem, vines 2-3 ft., large pods,...........	Medium, ...	6.5	18.
Iron, ...	"	Erect to trailing, vines 2 ft., plant 2½ ft., tall, vigorous,..	Medium, ...	8.6	10.
Red Carolina, ...	"	Trailing, vines 3-4 ft., large pods, ...	Medium, ...	5.7	13.
Rice, ...	"	Trailing, vines 2-3 ft., but few pods, ...	Late, ...	6.9	3.
Extra Early Blackeye,..........	"	Trailing, vines 3-5 ft., well podded, ...	Early, ...	6.0	11.
Hollybrook Soy Bean,...........	"	3½ ft., tall, vigorous, ...	Medium, ...	5.4	16.



Whippoorwill Cowpea. Red Ripper Cowpea.

Soiling Crop Experiment.



Iron Cowpea. Soiling Crop Experiment. Michigan Favorite Cowpea.

Field Crops.

Alfalfa.—Two Acre Experiment. Plot 29. Since 1896 this plot was used as an exercise and feeding yard for cattle. Every summer as often as possible, the droppings from the animals were gathered up and utilized on the farm, nevertheless, considerable fertility was added to the soil in the organic form. The soil was of red shale character, but had a larger proportion of sand than the average soil on the farm. The location was high and well drained. The field was broken up in the spring of 1906 and planted to peas and oats. No manure or fertilizer was applied. The growth was very rank, some of the Canada pea vines measuring six feet, and the yield was 2.6 tons of well cured hay per acre. In July of that season the land was plowed and allowed to lie fallow with occasional surface harrowings until August, when three tons of stone lime or one and one-half tons per acre was applied in the freshly slaked form. The land was carefully fitted, 100 pounds of ground bone, 250 pounds of acid phosphate and 100 pounds of muriate of potash per acre was applied and seeded to alfalfa, applying 25 pounds of seed per acre. The seeding was done just preceding a rain and covered with a spike smoothing harrow. The stand of plants was thick and even, and they attained six inches growth before winter. No topdressing of manure or other mulching was used, and the field wintered well and made an excellent start in the spring. None of the plants heaved, however, a roller was used as early as we could get on to the field.

Four cuttings have been taken off. The first cutting made May 10th, two weeks later than usually. The first three cuttings were made into hay, while the fourth was fed green to the cattle. The yield is as follows:

	Hay. Tons.	Green Fodder. Tons.
First cutting, May 10,	5.49	....
Second cutting, July 9,	3.77	....
Third cutting, August 19,	2.00	....
Fourth cutting, September 25,	....	5.6
Total,	11.26	5.6

Total, equivalent to 12.50 tons of hay.

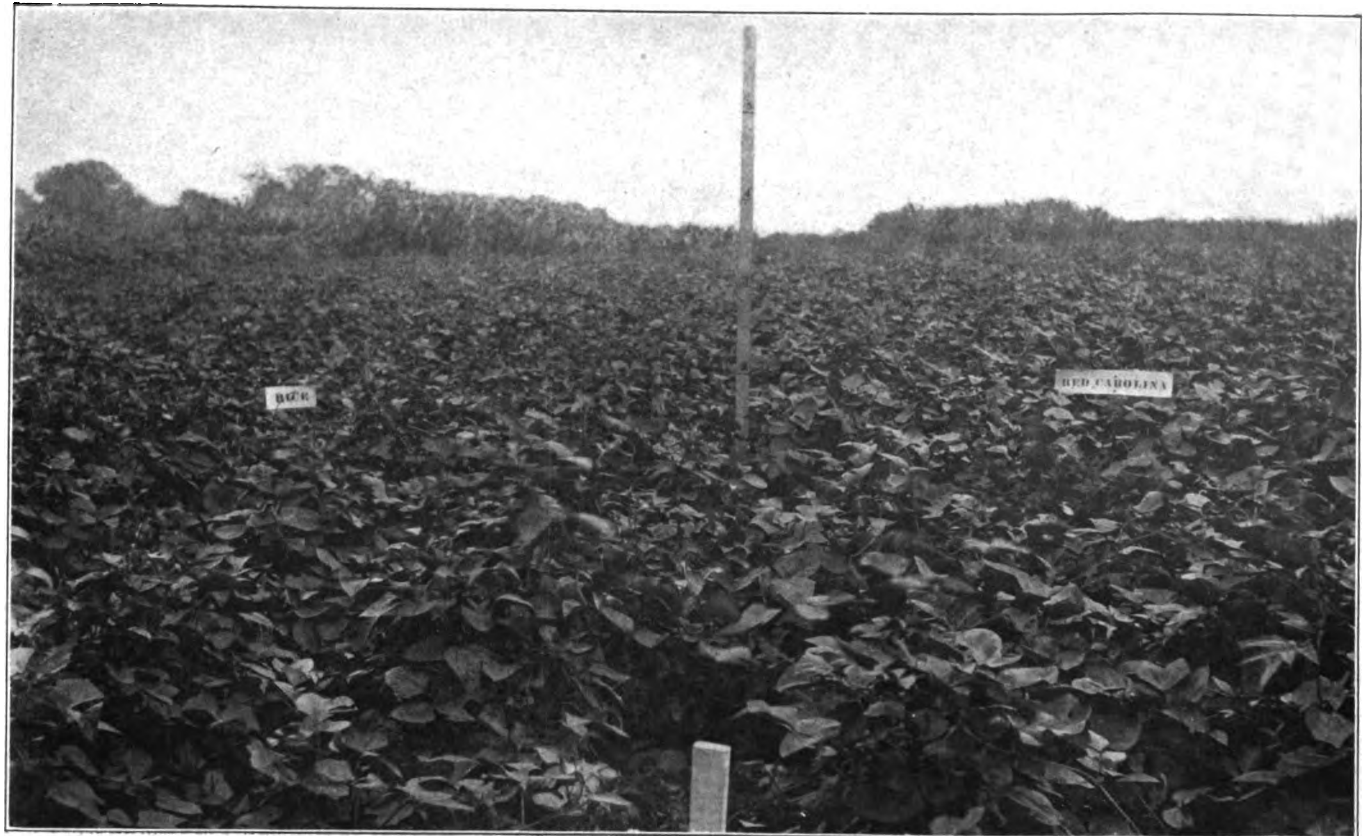
Average yield per acre, 6.25 tons of hay.

One-half of the field was inoculated with soil from our old alfalfa field, but no difference could be seen in the growth of plants in the inoculated portion and it is quite probable that the alfalfa bacteria was carried to the field on the alfalfa fodder fed to the cattle in previous years.

This yield of alfalfa hay, the first year after planting, exceeds any record made in previous years on the College Farm. It shows the possibilities of the crop in New Jersey under proper conditions of soil and cultivation. The cost of fitting the soil, fertilizers and seed, including lime, amounted to $31.25 or $15.62 per acre. Charging all the cost of seeding to the first year's crop, the cost of growing, not including cost of harvesting, was $2.34 per ton. Including the cost of harvesting, which was $19 per acre, the total cost amounted to $34.62 or $5.54 per ton of hay. At $20 per ton, which was the value of the hay as hauled from the field, the total income per acre was $125. Deducting cost of growing and harvesting, the net gain per acre was $90.38 or 261%. A dressing of 150 lbs. acid phosphate and 50 lbs. of muriate of potash per acre was given in September, and the result has been to make a vigorous growth as a mat for winter protection.

Disking Alfalfa in September.

Experiments in disking alfalfa in spring and summer has not been very successful, for while it cut out many of the weeds for the time, a new crop soon started, and before the season finished the field was about as badly infested as before. Very few new weeds start after September 1st, and by disking the crown is split and a larger head is formed. Plot 16 and 17, two acres, was fitted at the same time as the preceding alfalfa experiment, but unfortunately a rain interrupted the seeding which made subsequent harrowing necessary. Dry weather followed, considerable of the seed did not germinate and the stand was thin in spots which allowed chickweed and grass to get a foothold in September. At the time of disking the field was badly infested. It was disked three times and reseeded with 10 pounds per acre of alfalfa seed, with a top dressing of 150 pounds of acid phos-



Rice Cowpea. Red Carolina Cowpea.

Soiling Crop Experiment.

phate and 50 pounds of muriate of potash per acre. All the old plants put on a strong vigorous growth by the treatment, the field is free from weeds, and the prospect for a good crop next season is very encouraging.

Experiment with Alfalfa Seed from Washington.

This experiment was started two years ago, and a general plan with result of the first season's cuttings was published in the Experiment Station Report for 1906. Three cuttings, June 15th, July 22d and August 31st were made into hay; the fourth cutting which amounted to only 720 pounds per acre of green fodder, was not considered in the comparison of plots. Nine plots representing seed from eight States is given in Table XII.

TABLE XII.

Yield of Hay per Plot and per Acre.

	1st Cutting.		2d Cutting.		3d Cutting.		Total.	
	Per Plot. lbs.	Per Acre. tons.	Per Plot. lbs.	Per Acre. tons.	Per Plot. lbs.	Per Acre. tons.	Per Plot. lbs.	Per Acre. tons.
Ontario, ...	300	2.13	90	.64	50	.36	440	3.13
Arizona, ...	350	2.49	100	.71	250	1.78	700	4.98
Minnesota, ...	320	2.27	110	.78	210	1.49	640	4.54
Kansas (1),...	330	2.34	120	.85	260	1.84	710	5.03
Kansas (2),...	300	2.13	120	.85	210	1.49	630	4.47
Utah, ...	330	2.34	125	.89	295	2.09	750	5.32
Texas, ...	270	1.92	130	.92	220	1.56	620	4.40
Wyoming, ...	300	2.13	110	.78	310	2.20	720	5.11
Wisconsin, ...	200	1.42	90	.64	155	1.10	445	3.16

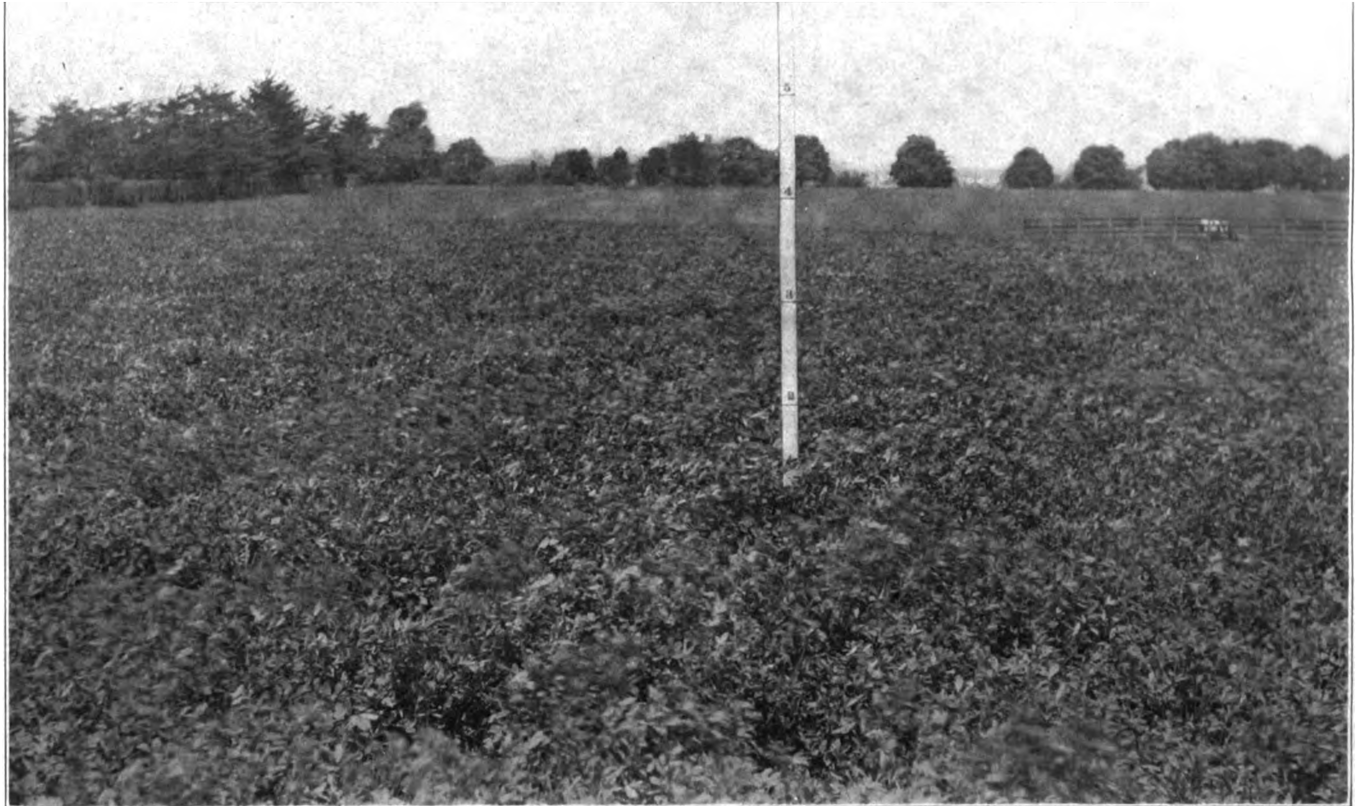
In total yield of hay the rank will be as follows: Utah, first; Wyoming, second; Kansas (1), third, and Arizona, fourth. This agrees quite closely with the result of last season, giving in both cases first rank to Utah. The experiment thus far indicates that in purchasing seed, aim to get that grown in a medium latitude including Utah, Kansas or Wyoming. In respect to foreign seed

the condition of the plot was such that this part of the experiment had to be discontinued.

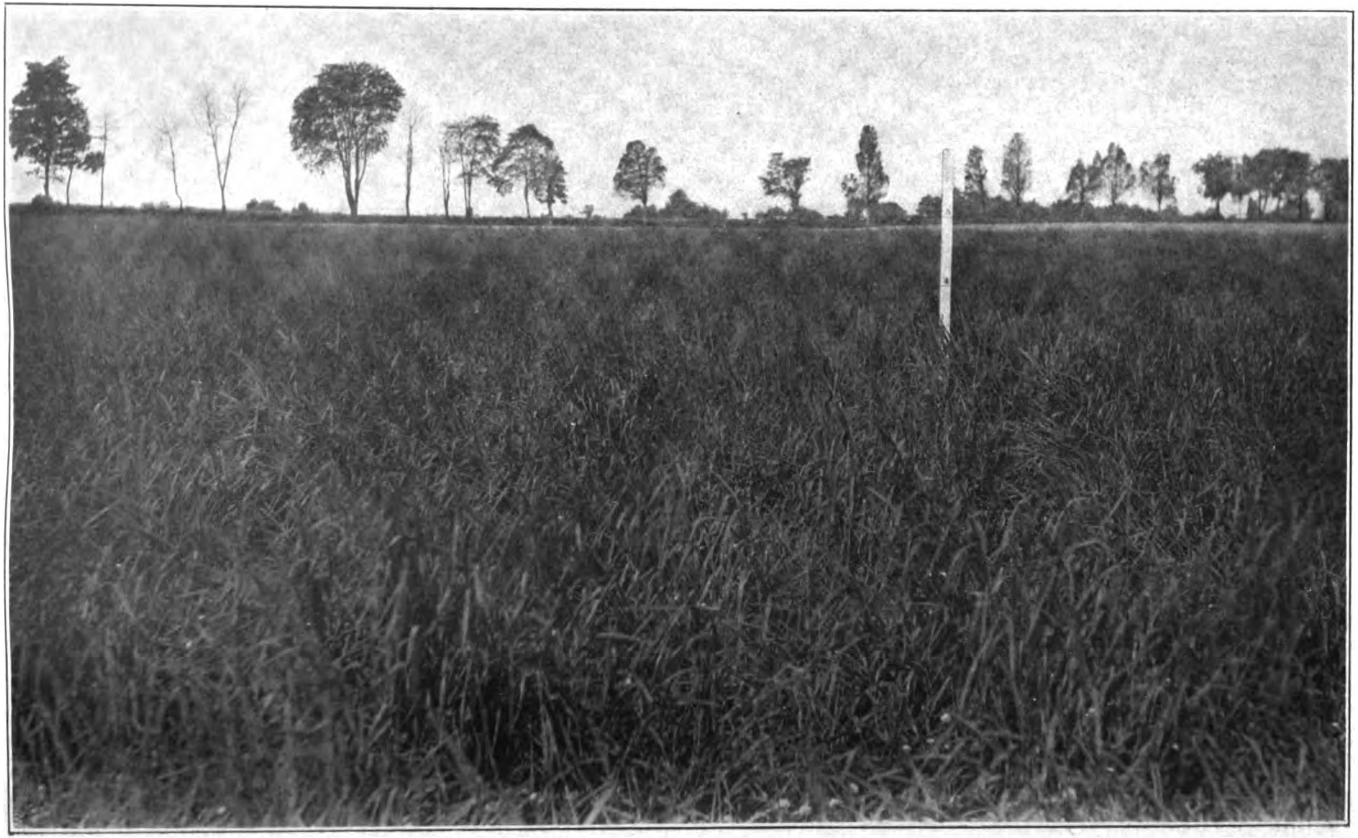
Timothy and Clover.—Four acres, Plots 1 to 4, seeded last August to clover and timothy gave for the first crop a yield of 16.4 tons or 4.1 tons per acre of hay. It had three to four days of fine weather in curing and was as dry as could be made in the field. The soil is a heavy red shale and, in places, with considerable Alloway clay. It is exceedingly hard to work, bakes in dry weather and has to be immediately harrowed after plowing else the lumps get hard and the cultivation unmanageable.

The history of this field for the past seven years is as follows: From 1900 to 1904 inclusive, it was planted successively to corn for the silo, with a catch crop of crimson clover used for soiling and hay in 1901 and 1903. During this period, manure was applied twice, 1902 and 1903, about 9 tons per acre, and the applications of fertilizers have been moderate. In 1905, three acres of this field had a dressing of 6 tons of manure per acre, and the four acres were seeded to oats and peas, yielding 2.7 tons of hay per acre. In August, 1905, 400 pounds of Peruvian Guano and one ton or 25 bushels stone lime, slaked and applied, and the field fitted and seeded to alfalfa. Either from poor seed or soil conditions the alfalfa blighted and the field was planted to oats and peas again the following spring. One hundred and fifty pounds of fertilizer per acre with a formula 5.25–10.5–8.75, was applied for this crop and a yield of 2.16 tons of oat and pea hay per acre was taken off. August 28 to 30, 1906, this field was seeded to timothy and clover, 9½ pounds timothy, 5 pounds red clover and 2½ pounds of alsike clover per acre, and 250 pounds of Chincha Island Peruvian Guano, 100 pounds acid phosphate and 100 pounds of muriate of potash was applied per acre, a mixture containing 4.2% nitrogen, 9.4% total phosphoric acid and 12.3% potash.

The grass was thick at the bottom with considerable alsike clover and the timothy was badly lodged. In cutting, it took two or three helpers with the machine to clear the track for the next round. The expense of cutting and hauling the hay was as follows: Mowing $6, teddering $4.80, raking $1 and carting



Alfalfa 10 inches tall seven days after hauling the hay from the first cutting.



Clover and Timothy. Yield, 4.1 tons of hay per acre.

and putting in barn $21.00, or a total of $32.80, equal to $2 per ton. The expense of seed, fertilizer and labor of seeding was $58.20, or $3.55 per ton, making a total cost of $5.55 per ton of hay. Assuming the hay to be worth $20 per ton as drawn from the field, and this is a fair price when hay sells in the market for $25.00, the net profit from a ton would be $14.45, or $59.24 per acre. The income, therefore, from the four acre field, after deducting total cost of seeding and harvesting, is $236.98.

A second cutting was made September 3d to 10th, and fed green to the herd of cows. The yield was 10.4 tons of fodder, equivalent to 2.3 tons of rowen hay. This gives a total for the season of 18.7 tons or 4.7 tons per acre.

Oats and Peas.—A two-acre plot, P and Q, was seeded April 4th to oats and peas; the amount of seed used was 2 bushels Swedish oats and 1½ bushels Golden Vine Canada peas per acre. An application of 10.7 tons of barnyard manure and 100 pounds of fertilizer was applied just before seeding. The yield was 5.98 tons, or 2.99 tons per acre of hay. In estimating the cost of growing, one-half of the manure was charged to a crop of cow peas which succeeded it. The cost of manure and fertilizer was $18.74, of seed $6.30 and of labor, including harvesting of hay, $19.20, or a total cost of $44.24. The cost per ton, therefore, was $7.32. At $18 per ton, as the value of the hay, the net gain per ton was $10.68, or 146%.

Four-Year Rotation Experiment.

The rotation more commonly practiced in New Jersey is, corn, oats, wheat and grass. These crops depend largely on the soil for their plant food where only a few animals are kept on the farm and for two seasons at least, after oats and wheat, the land lays bare, subject more or less to loss by washing or leaching. Furthermore, this method may result in the destruction of soil bacteria which are necessary in making available the plant food in the soil. Where barnyard manure is applied to the corn crop, a more economical use of manure is secured and the organic

matter supplied will be of assistance to succeeding crops in the rotation.

Object of Experiment.—The aim is to learn if by growing cover crops, loss of soluble plant food and surface washing on hillside and slopes cannot be prevented, at the same time increasing fertility of the soil by conversion of plant food into organic forms, particularly the nitrogenous portion which would be washed away; promote a better mechanical condition, by regulating temperature and moisture conditions. The deep-rooted clovers will assist in making the soil more friable and add humus to assist in making the moisture more favorable.

Plan of Experiment.—Since oats are not a very profitable crop in this state, substitution of corn was made in one rotation and potatoes in another. The three rotations as outlined are, first,—corn, oats, wheat and grass; second,—corn, corn, wheat and grass, and third,—corn, potatoes, wheat and grass.

Plan of Rotation.

Periods.	Rotation I.		Rotation II.		Rotation III.	
	Plot A. No Cover Crop.	*Plot B.* Cover Crop.	*Plot C.* No Cover Crop.	*Plot D.* Cover Crop.	*Plot E.* No Cover Crop.	*Plot F.* Cover Crop.
1907	Corn	Corn Rye	Corn	Corn Crimson Clover	Corn	Corn Rye
1908	Oats	Oats Cow Peas	Corn	Corn Cow Peas	Potatoes	Potatoes Cow Peas
1909	Wheat	Wheat Cow Peas	Wheat	Wheat Cow Peas	Wheat	Wheat Cow Peas
1910	Grass	Grass	Grass	Grass	Grass	Grass

Two plots were assigned for each rotation, one without the use of additional cover crops as generally practiced, the other, using rye, crimson clover and cow peas either to be turned under

Clover and Timothy. Yield of first crop, 4.1 tons of hay per acre.

or made into hay. In rotation I. rye is seeded at the last cultivation of corn to be turned under the following spring. The land disked and seeded to cow peas immediately after harvesting of oats, to be made into hay the latter part of September in time for the planting of wheat. The next year cow peas will succeed wheat and cut in time for the seeding to grass. In rotation II. crimson clover succeeds corn the first year, cow peas seeded broadcast in corn at the last cultivation in July of the second year and to follow wheat the third year as in rotation I. In rotation III. rye is sown in corn at the last cultivation, cow peas follow potatoes the second year and wheat the third year as in other rotations. Samples of soils were taken from each plot at the beginning of the experiment for chemical analysis and examination for soil bacteria and samples for similar examination will be taken at the close of the experiment. Each plot was 296 feet long and 22 feet wide allowing three feet between plots. Each, therefore, represented .15 of an acre. This acre field had an application of 12.5 tons of manure and 200 pounds of fertilizer, equivalent to 87 pounds nitrogen, 100 pounds phosphoric acid and 140 pounds of potash.

Results of First Year's Rotation.—Seven rows planted in hills 3½ feet apart to Gold Standard Leaming. Each hill was thinned to two stalks. The yield of No. 1 corn, allowing 80 pounds of green corn to the bushel, is as follows:

	Per Plot.		At the rate Per Acre.
	Lbs.	Bu.	Bu.
Plot A,	900	11.25	75
" B,	850	10.65	71
" C,	850	10.65	71
" D,	950	11.87	79
" E,	950	11.87	79
" F,	900	10.63	75
Average,			75

The corn stalks have not been hauled at this writing. Nearly every stalk bore a mature ear.

Fertilizer Rotation Experiment.

Another acre separated only by a strip 50 feet in width from the preceding rotation experiment plot was divided and planted in the same manner, to be followed by the same rotations with the provision for cover crops as arranged in the preceding plan. The object being to study the effect of ground rock phosphate and basic slag as compared with the more soluble forms of phosphate. The application was as follows:

Rotation I. Plots A and B—

Nitrate of Soda,	75 lbs.	Per acre.
Acid Phosphate,	200 "	
Muriate of Potash,	40 "	

Rotation II. Plots C and D—

Nitrate of Soda,	75 lbs.	Per acre.
Basic Slag,	300 "	
Muriate of Potash,	40 "	

Rotation III. Plots E and F—

Nitrate of Soda,	75 lbs.	Per acre.
Ground Phos. Rock,	400 "	
Muriate of Potash,	40 "	

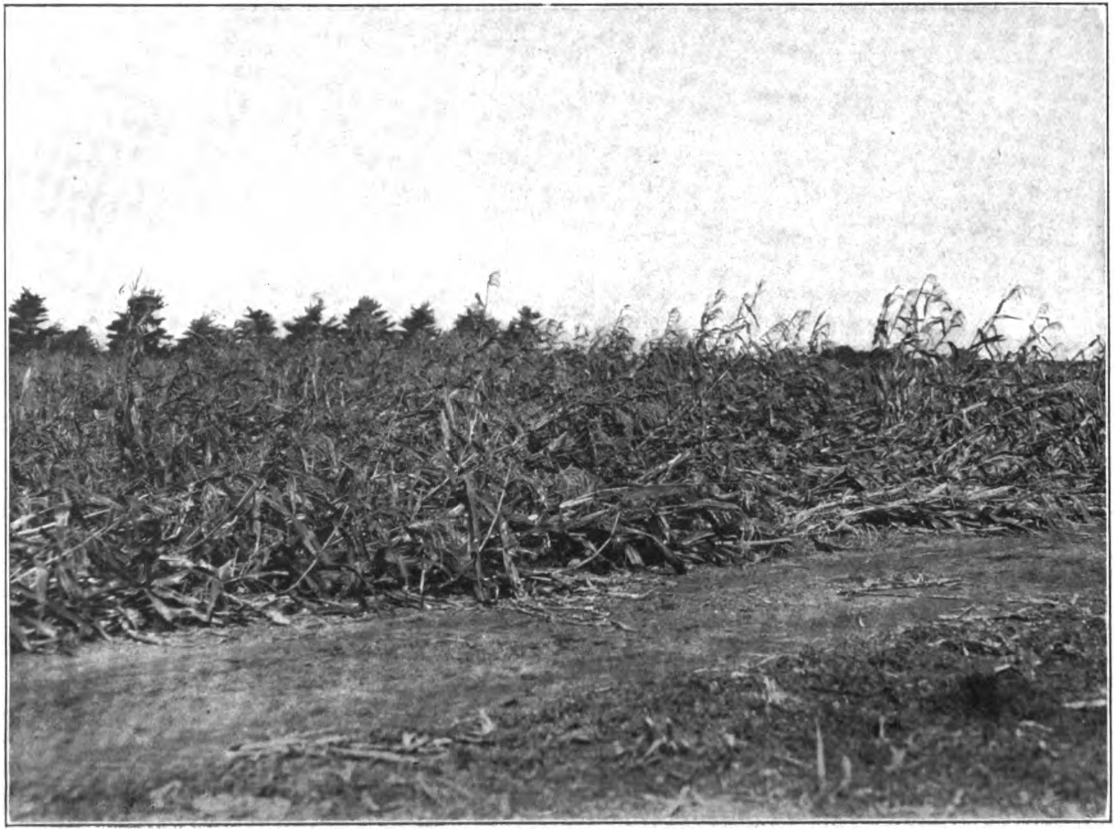
10.7 tons of barnyard manure was applied during the winter. Comparison will be made with the rotation on the same field and also with the corresponding plot of the rotation experiment. The amount of raw phosphate applied was made on a basis of cost rather than total phosphoric acid.

The cost of fertilizer applied to each rotation per acre is as follows:

	Nitrate.	Phosphate.	Potash.	Total.
Rotation I,	$1 95	$1 34	$0 82	$4 11
Rotation II,	1 95	2 40	82	5 17
Rotation III,	1 95	2 40	82	5 17

The yield of No. 1 Leaming corn was:

Rotation I,	1,600 lbs.	equivalent to 62½ bu. per acre.
Rotation II,	1,700 "	" " 71 " " "
Rotation III,	1,500 "	" " 67 " " "



Silage Corn. Damaged by storm, requiring hand cutting.

If we compare the three rotation plots with each other, there seems to be a little advantage in yield from the application of raw phosphates but no definite conclusion can be drawn from one year's result. Basic Slag contains a large per cent. of lime which may partially account for the slight increase in yield. The cropping and method of tillage for the past two years had been quite uniform in both of the rotation experiment areas.

Fertilizer Experiment with Silage Corn.

An experiment to study the effect of basic or phosphate slag as a source of phosphoric acid for field crops was started last year and the result from the first year's application was published in the Report for 1906. The test was continued, using only one-half of the amount of each ingredient per acre. The application was as follows:

R, S, T, 3 acres (Plot 1)—

Nitrate of Soda,	100 lbs.	
Basic Slag,	200 "	Per acre.
Muriate of Potash,	75 "	

U, V, W, 3 acres (Plot 2)—

Nitrate of Soda,	100 lbs.	
Ground Bone,	50 "	
Acid Phosphate,	175 "	Per acre.
Muriate of Potash,	75 "	

X, Y, Z, 3 acres (Plot 3)—

Nitrate of Soda,	100 lbs.	
Peruvian Guano,	100 "	
Ground Bone,	50 "	Per acre.
Acid Phosphate,	100 "	
Muriate of Potash,	75 "	

Southern white corn was planted in drills three feet apart. The season was very unfavorable for this variety which requires a hot moist season for maturing in this latitude. The stalk did not reach nearly the usual height, smaller, with a small proportion of ears, none of which reached maturity. The soil was cold and the moisture conditions influenced by the seasons, particularly on plots X, Y, Z. The total yield of fodder was as follows:

Plot 1,	33.02 tons, or	11.0 tons per acre.	
Plot 2,	24.82 " "	8.3 " " "	
Plot 3,	21.65 " "	7.2 " " "	

These reports compare very closely with those of last season, indicating that basic slag as a source of phosphoric acid will produce very satisfactory results.

Cost of Silage.

The cold backward spring, the dry weather in July and August, with the increase in cost of farm labor has greatly increased the cost of production of corn silage. A much larger area had to be cut over to get the same amount of corn and there was a scarcity of large mature ears. While a few acres cut 10 to 12 tons of corn fodder, late corn yielded but 6.7 tons and the average was 8.2 tons per acre. Only 213 tons were taken from 26 acres as compared with 225 tons from 18 acres in the season of 1906. The increase in the amount ensiled last year was due to the greater number of ears. The cost of growing the corn, cutting and filling the silos is as follows:

Cost of cutting and filling:		
Engine, coal and man,		$56 25
Team work,		122 00
Labor,		200 00
Total,		$378 25
Number of tons cut,	213	
Cost per ton,	$1 77	
Cost of growing:		
Seed, manure, fertilizer and labor,		$386 70
Cost per ton,	$1 73	
Total cost of Silage per ton,	$3 50	

Hay Caps.

The use of hay caps in the curing of alfalfa hay has been continued and an additional number of caps were provided by purchasing 45-inch cotton sheeting and cutting them square.

First cutting Alfalfa. Yield, 2.74 tons of hay per acre. Showing the use of hay caps.

Harvesting Corn for the Silo. The corn binder could not be used and all the forage had to be handled loose.

These were weighted with a piece of iron on each corner. The advantage of hay caps was proven in the harvesting of the first cutting of hay. A two-acre field was partially cured and put in cocks, and one-half of these were covered with caps. A hard beating storm came up, which lasted for twenty-four hours, thoroughly wetting the uncovered hay cocks, making the hay more or less bleached, the stem brittle, incurring a loss of leaves Where caps were provided the hay was damp only two or three inches below the cap and a little on the side where the cap did not cover. The hay was spread out in the forenoon and was dry enough to cart in the afternoon, whereas, where no caps were provided it took the second day to cure it. Furthermore, the hay was enough better in quality to justify the expense. Where only a few are used a wheel barrow is very good for distributing them, but a drag or a cart used only for this purpose should be provided where a large number are used. Care should be taken to get the caps dry to prevent mildew after each wetting.

III. THE DAIRY HERD.

Cost of Producing Milk.

The advance in price of feed has increased to some extent the cost of producing milk, but it is chiefly since April 1st that the increase in price of all mill feeds has taken place. During the year ending April 1st, 1907, bran advanced from $20.50 to $24.00 per ton. The increase in dried brewers' grains made it too expensive for the food nutrient received, and dried corn distillers' grains were purchased in their place. Among the very concentrated feeds cotton seed meal still remains the cheapest source of protein. Soiling crops cost $1.82, silage $2.55 per ton, and alfalfa hay makes the most economical roughage. Since ten tons of good alfalfa hay is equivalent to nine tons of bran in feeding value, when alfalfa hay grown on the farm costs on an average $6 to $7 per ton, it is an important factor in reducing the feed bill. Corn silage and alfalfa hay, with two pounds of cotton seed meal per day has been fed at the College Farm with

a decrease of but 4% in yield of milk. Alfalfa is being successfully grown in many parts of the State and therefore the growing of alfalfa, crimson clover, red clover and cow peas should be encouraged and thus eliminate to a certain extent the purchase of concentrated feed, which at the present high prices is a serious problem for the dairyman. Corn silage was of excellent quality, high in per cent. of dry matter and fed with practically no waste. Records were kept of the cost of purchased feeds; all the roughage was charged to the herd at actual cost of production, including seed, manure and fertilizers and labor.

The outline of the cost of feeds consumed by 31 cows during the year ending April 1st, 1907, is as follows:

Cost of Foods.

Roughage.		
Corn Silage,	$310 00	
Soiling Crops,	260 00	
Oat and Pea Hay,	84 00	
Alfalfa Hay,	54 00	
Corn Stalks,	65 00	
		$773 00
Feeds.		
Wheat Bran,	$290 00	
Ground Oats,	7 50	
Cottonseed Meal,	14 00	
Gluten Feed,	37 50	
Dried Brewers' Grains,	93 00	
Dried Dist. "	172 00	
Corn Meal,	20 00	
Dried Beet Pulp,	14 00	
		$648 00

Total cost of food consumed by 31 cows,	$1,421 00
Average cost of food per cow,	45 84
Cost of roughage per day,	2 12
Cost of roughage per cow daily,	6.8 cts.
Cost of feed per day,	1 77
Cost of feed per cow,	5.7 cts.
Cost of roughage and feed per cow daily,	12.5 cts.

Total milk produced,	194,947.7 lbs.
Total milk produced,	90,845.6 qts.
Total butter produced,	9,958.8 lbs.
Average milk per cow daily,	8.03 qts.

	Cost of Roughage.	Cost of Feeds.	Total.
100 lbs. milk,	39.64 cts.	33.23 cts.	72.87 cts.
1 qt. milk,	.85 "	.71 "	1.56 "
1 lb. butter,	7.76 "	6.51 "	14.27 "

Notwithstanding the advance in feed since 1906, the average cost of food per cow for the year ending April 1st, 1907, was $45.84, three cents less than the average for the previous year. This is explained by the greater amount of alfalfa grown on the farm, and by the purchase of high grade corn distillers' grains, in carload lots at wholesale price. Since protein is the element of nutrition deficient in forage crops, greater care should be exercised in the selection of feeds for the dairy, which furnish the greatest amount of digestible protein for a dollar and cottonseed meal, high grade distillers' grains, gluten and dried brewers' grains rank in the order given.

The feed cost of production of 100 pounds of milk was 72.87 cents, of which the roughage was 39.6 cents and the feeds 33.2 cents. The cost of one quart of milk was 1.5 cents and one pound of butter 14.27 cents.

The income from the herd with milk at 3 cents and 4 cents per quart and butter at 22 cents and 28 cents per pound is as follows:

	Average cost of food per cow.	Income, average, 81 cows.	Amount received above cost of food.
Milk @ 3c. per qt.,	$45.84	$87.92	$42.08
" " 4c. " "	45.84	117.22	71.38
Butter @ 22c. per lb.,	45.84	70.69	24.85
" " 28c. " "	45.84	89.96	44.12

The amount received above the cost of food with the manure represents the amount received from each animal for labor. At $1.00 per hundred, or 2.15 cents per quart, the income per cow above cost of food was $17.04. At 22 cents per pound for butter, but $24.85 per cow with the manure, or $770 for the herd, is the amount received for labor. The value of the skim milk would offset the cost of making the butter.

The average cost of milk, including foods consumed, labor, interest on and increase in the value of the herd is as follows:

Food as per statement,	$1,421 00
Labor,	1,000 00
Interest on the herd at 5%,	100 00
Decrease in the value of the herd at 12½%,	250 00
Total,	$2,771 00

Cost of food per qt. of milk,	1.56 cts.
Cost of labor, interest and decrease on herd, per qt. of milk,	1.48 "
Total cost of milk,	3.04 "

At 4 cents per quart the receipts would have amounted to $3,633.82. Deducting the cost of purchase feeds, labor, interest on and decrease in the value of the herd, amounting to $1,998, we have a balance of $1,602.44, which represents the value of home-grown crops. In other words at 4 cents per quart for milk the farm would sell to the dairy pea and oat hay at $18, alfalfa at $18, corn silage at $5, soiling crops at $3.50 and corn stalks at $4 per ton. At 4 cents per quart, the farmer does not receive full market rates, at the present time, for his hay or corn, even when no interest is charged on the investment in land and buildings. The cost of food, interest on and decrease in the value of the herd is $1,771. Deducting this from $3,633.82, or the amount received when milk is at 4 cents, leaves a difference of $1,862.82, or 86% above the actual cost of labor.

The fertilizer ingredients added to the farm through the purchased feeds are as follows:

	Nitrogen.	Phosphoric Acid.	Potash.
Wheat Bran,	675.8	770.8	414.5
Ground Oats,	8.9	3.8	2.5
Cottonseed Meal,	99.9	43.2	25.5
Gluten Feed,	116.1	11.1	1.2
Dried Brewers' Grains,	361.7	88.9	7.0
Dried Distillers' Grains,	530.6	84.	238.
Corn Meal,	28.8	12.6	7.4
Sugar Beet Pulp (dry),	18.9	3.6	7.5
Total,	1,840.7	1,018.0	703.6

The fertility added to the farm from purchased feeds is equivalent approximately to 150 tons of barnyard manure and 3 tons of nitrate of soda.

Records of the Dairy Herd.

Table XIII. gives the yearly record and the best monthly and daily record of those animals which have been in the herd continuously for one year. Of the 31 cows recorded, there are three pure bred Holsteins, seven pure bred Aryshires, one pure bred Jersey and twenty grades. The three Holsteins averaged 9,405 pounds of milk and 412 pounds of butter. Hilda 2d, a two year old, gave 7,133 pounds of milk and 306 pounds of butter, while Colantha produced 13,431 pounds of milk and 530 pounds of butter. We often consider Holsteins profitable only for milk, yet Colantha made the largest record for butter of any cow in the stable. While no accurate account has been made of any individual cow, it is probable that the cost of the food she consumed did not exceed $15 more than for the average cow in the herd, or approximately $60. At 4 cents per quart, the wholesale price of milk in this region, the income for her milk would amount to $250.35. Deducting the cost of food, $60, and labor, etc., $43.50, leaves a net gain of $146.85, or 142%, certainly a good investment since seven such cows would pay for all the labor necessary to care for 31 animals, or 19 cows would return a net gain sufficient to cover the total expense on such a herd.

The seven pure bred Ayrshires averaged 5,454 pounds of milk and 271 pounds of butter, which at 4 cents for milk and 28 cents for butter would have amounted to $101.66 and $75.88 respectively for milk and butter. Among the grade cows only three fell below the 5,000 pounds mark for milk, which is the lowest yearly record an animal can make profitable.

TABLE XIII.

Individual Record of Dairy Herd—One Year.

NAME OF COW.	BREED.	April 1, 1906–April 1, 1907.				Best Monthly Record.		Best Daily Record.	
		Milk. lbs.	Fat. %	Fat. lbs.	Butter. lbs.	Milk. lbs.	Fat. lbs.	Milk. lbs.	Fat. lbs.
Viola,	G. Holstein,	5502.4	5.44	299.5	349.4	779.6	35.86	29.1	1.34
Hilda,	Reg. Holstein,	7650.7	4.47	342.2	399.2	768.6	33.04	28.3	1.22
Model,	G. Jersey,	6390.5	3.82	244.5	285.3	990.1	34.65	36.9	1.29
Select,	G. Shorthorn,	6671.4	4.16	278.0	324.2	969.4	41.68	34.5	1.48
Gypsey,	G. Jersey,	5079.9	4.37	222.4	259.5	743.6	31.97	30.1	1.29
Diana,	G. Holstein,	7757.6	4.32	335.6	391.5	962.7	41.39	36.0	1.55
Pearl,	G. Holstein,	7059.1	4.25	338.8	395.3	1126.3	48.43	40.9	1.76
Myrtle,	G. Jersey,	4875.1	4.45	217.2	253.3	699.9	33.59	26.2	1.26
Victoria,	G. Holstein,	8592.4	3.79	325.5	379.7	1334.6	49.38	47.4	1.75
Beula,	G. Jersey,	6796.9	4.80	326.5	380.9	750.4	34.51	27.5	1.27
Genesta,	G. Jersey,	5112.9	4.64	237.6	277.2	885.0	41.59	32.5	1.53
Perfection,	G. Guernsey,	5706.4	4.35	248.6	290.1	813.4	34.97	29.8	1.28
Evesta, 8th,	P. B. Ayrshire,	5583.2	4.22	236.0	275.3	782.2	32.07	24.5	1.00
Cherry,	Reg. Ayrshire,	5414.4	4.41	238.9	278.2	1044.9	47.02	40.0	1.80
Regena, 4th,	P. B. Ayrshire,	4922.4	4.31	212.3	247.7	682.7	25.94	27.0	1.05
Queen's Ideal,	G. Guernsey,	8926.7	4.66	416.8	486.3	934.7	50.47	37.2	2.01
Queen,	G. Holstein,	4684.2	4.13	193.6	225.8	1012.2	41.50	43.6	1.79
Alta,	G. Ayrshire,	6197.0	4.38	271.8	317.1	1090.1	45.78	38.6	1.62
Sebolt,	G. Guernsey,	5156.7	5.25	271.0	316.3	901.7	45.98	33.7	1.72
Evesta, 9th,	P. B. Ayrshire,	5520.2	4.43	244.7	285.5	867.6	31.23	33.0	1.19
Evesta, 7th,	Reg. Ayrshire,	5539.8	4.41	229.3	267.6	752.0	27.82	25.5	.94
Regena, 5th,	P. B. Ayrshire,	4700.9	4.24	199.6	232.8	726.1	29.04	29.0	1.16
Yolande,	G. Jersey,	4291.5	4.44	190.7	225.6	648.5	26.58	22.8	.95
Hilda, 2d,	P. B. Holstein,	7133.5	3.68	262.8	306.6	775.1	27.90	29.6	1.37
Colantha,	Reg. Holstein,	13431.3	3.38	454.5	530.2	1670.7	55.13	62.8	2.07
Select, 2d,	G. Guernsey,	4594.4	5.16	237.5	277.0	608.4	33.52	30.0	1.44
Pearl of Grouville,	Reg. Jersey,	4614.9	5.96	274.9	320.7	610.4	35.40	26.0	1.51
Black,	G. Holstein,	6733.3	4.20	283.4	330.6	1133.3	46.46	40.4	1.66
Cherry's Lassie,	Reg. Ayrshire,	6501.0	4.08	265.5	309.8	942.8	35.82	32.5	1.24
Queens, 5th,	G. Guernsey,	7037.0	4.90	345.4	403.0	944.6	47.23	34.4	1.72
Queen's Ideal, 2d,	G. Guernsey,	5870.0	4.92	288.9	337.1	685.5	30.16	24.6	1.08
Average,		6288.6	4.38	275.3	321.3	894.4	37.94	33.4	1.43

Three classes could be made from the above table, namely, those valuable for the production—first, milk; second, butter, and third, milk and butter.

Class 1. Yield of Milk.

1	cow	over	10,000	lbs.						
2	cows	"	8,000	"	and under	10,000	lbs.	of	milk.
5	"	"	7,000	"	" "	8,000	"	"	"
6	"	"	6,000	"	" "	7,000	"	"	"
10	"	"	5,000	"	" "	6,000	"	"	"
7	"				"	5,000	"	"	"

At $1.00 per 100 lbs., or 2.15 cents per quart of milk, the seven cows producing less than 5,000 lbs. of milk averaged $46.69 per cow, or 85 cents each above the actual cost of feed. At 3 cents per quart each cow would average $65.27, or $19.43 each above the average cost of food. Milk would have to sell at 4 cents per quart in order to pay for their feed and care. Animals which bring no profit above the cost of feed and labor should not be kept in the herd.

Class 2. Yield of Butter.

1	cow	over	500	lbs.					
2	cows	"	400	"	and under	500	lbs.	of	butter.
4	"	"	350	"	" "	400	"	"	"
10	"	"	300	"	" "	350	"	"	"
10	"	"	250	"	" "	300	"	"	"
4	"				"	250	"	"	"

At 20 cents per lb. the four cows yielding less than 250 will only pay for the food they eat, and butter must sell for 38 cents per pound in order to pay for their food and labor.

Class 3. Yield of Milk and Butter.

Colantha,	13,431	lbs.	of	milk	and	530	lbs. of	butter.
Queen Ideal,	8,926	"	"	"	"	486	" "	"
Queen's 5th,	7,037	"	"	"	"	403	" "	"
Pearl,	7,959	"	"	"	"	395	" "	"
Hilda,	7,650	"	"	"	"	399	" "	"
Diana,	7,757	"	"	"	"	391	" "	"
Victoria,	8,592	"	"	"	"	379	" "	"
Beula,	6,796	"	"	"	"	381	" "	"

These eight cows averaged 8,518 lbs. of milk and 420 lbs. of butter, and the average quality of milk was 4.22 per cent. At 4 cents per quart for milk the income above the cost of food and labor was $65.26 each, or a gain of 76 per cent.

REPORT OF THE HORTICULTURIST.

Report of the Horticulturist.

M. A. BLAKE, B. SC., HORTICULTURIST.
JENNIE A. VOORHEES, A. B., ASSISTANT.

The work of the horticultural department came under my supervision December 1, 1906.

Many of the experiments at the College farm had been continued for a series of years, and owing to the fact that they had been practically completed, the asparagus plots were plowed out, and also the blackberries, raspberries, currants and gooseberries. The peach and plum experiments with various fertilizer treatments were also discontinued.

The fertilizer experiment with apples, asparagus breeding, and the peach experiments at High Bridge have been continued.

Further experiments with apples, several tests with strawberries, an experiment with sterilized manure to control the mushroom maggot are some of the new lines of work undertaken at the College farm.

Another experimental peach orchard of 675 trees was set at Vineland last spring, and several tests were carried out in private orchards. A number of visits were made to peach growing sections of the State to determine diseases and other troubles.

The weather records and notes have been kept by Miss J. A. Voorhees and Mr. George D. Manning.

RECORDS OF TEMPERATURES AND RAINFALL.

An exceptionally late spring was experienced this year with cool weather extending into June; 39° minimum being registered upon the 13th of the month, which is a departure of 4.8° from the normal minimum and the lowest for the month since records have been kept at this station. On May 12th the minimum was 29°, which is 6.9° lower than the normal minimum.

The greatest daily ranges of temperature for May and June

were 41° and 34° respectively, that of the former month indicating severe extremes.

The summer months were not exceptionally warm; the extreme maximum for the three registered was 93° upon July 18th and August 8th.

The first killing frost at this station occurred on October 20th, though the month was characterized by low minimum temperatures.

The total precipitation for the year was 45.66 inches, which is 1.71 inches below the normal for this section. A severe local storm occurred upon July 18th when 4.06 inches of rain fell in a period of 4 hours.

TABLE I.

Daily and Monthly Precipitation in Inches at the College Farm, for the Year Ending October 31, 1907.

DATE.	Nov. 1906.	Dec. 1906.	Jan. 1907.	Feb. 1907.	Mar. 1907.	Apr. 1907.	May. 1907.	June. 1907.	July. 1907.	Aug. 1907.	Sept. 1907.	Oct. 1907.
1, ...	0.04	......	0.12	0.48	......	0.21	......	......	......	0.05	......	......
2, ...	......	......	......	......	0.24	......	......	1.04	0.35	T.	0.05	......
3, ...	......	T.	......	0.08	T.	......	......	0.02	......	......	......	......
4, ...	......	......	0.29	0.10	......	......	1.00	......	......	......	0.10	0.50
5, ...	......	......	......	1.25	......	......	......	0.21	......	......	......	T.
6, ...	......	0.42	......	......	0.04	......	0.29	......	......	0.29	......	0.07
7, ...	......	......	......	......	......	......	0.08	......	......	......	......	......
8, ...	......	......	T.	T.	1.40	0.52	......	......	......	......	0.03	1.36
9, ...	......	......	0.20	......	......	0.28	0.30	......	......	0.51	0.02	......
10, ...	......	0.24	......	0.04	0.31	T.	......	......	......	......	......	......
11, ...	0.43	0.52	......	T.	0.17	......	0.33	......	0.17	......	0.63	......
12, ...	......	......	1.23	......	......	T.	......	......	0.20	......	......	0.06
13, ...	......	......	T.	......	0.22	0.19	......	......	......	0.11	......	......
14, ...	......	......	0.47	......	0.08	......	......	0.71	......	......	......	......
15, ...	0.55	......	0.15	......	......	......	......	0.02	......	......	......	......
16, ...	0.20	0.17	......	......	......	......	1.05	......	......	0.13	......	......
17, ...	......	0.51	0.44	......	......	......	0.28	......	......	......	......	......
18, ...	T.	0.04	T.	......	0.10	......	......	......	4.06	......	0.34	......
19, ...	0.22	......	0.26	0.06	0.18	0.11	0.09	......	......	......	0.15	......
20, ...	......	0.56	T.	......	0.25	......	0.41	......	1.19	......	......	......
21, ...	......	0.12	......	......	......	......	......	0.15	T.	T.	0.37	0.08
22, ...	T.	0.06	......	......	......	......	......	......	......	......	0.13	......
23, ...	......	......	......	......	......	0.06	......	......	......	......	1.83	......
24, ...	......	......	......	0.15	T.	0.35	......	......	......	1.02	0.12	......
25, ...	......	......	T.	0.35	......	......	......	......	......	0.68	0.49	......
26, ...	......	......	0.15	......	......	......	0.18	0.28	......	......	......	......
27, ...	......	......	......	0.04	......	0.50	0.49	......	......	......	......	0.12
28, ...	......	T.	T.	......	......	......	......	......	......	......	0.84	1.85
29, ...	......	......	......	......	......	......	......	0.27	0.45	......	2.25	0.91
30, ...	......	0.19	0.13	......	......	......	......	0.74	......	......	......	......
31, ...	......	0.88	......	......	......	......	......	......	......	......	......	......
Total, ...	1.50	3.71	3.44	2.55	2.99	2.22	4.50	3.44	6.42	2.79	6.85	4.95
Normal, ...	3.74	3.66	3.82	3.64	3.77	3.68	4.02	3.80	4.92	4.93	3.94	3.45

Monthly Precipitation, in Inches, since January 1, 1896.

YEAR.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	Total Yearly.
1896,	.....	.....	1.68	5.85	5.92	1.41	3.70	4.93	4.37	2.42	4.81	1.62	*36.71
1897,	2.95	1.59	2.39	2.77	2.47	3.47	6.45	2.50	12.84	3.81	2.10	1.59	44.93
1898,	4.52	5.09	3.92	3.49	3.09	4.17	7.86	1.13	3.91	6.44	1.46	5.80	50.88
1899,	7.14	3.16	4.88	5.37	6.63	1.50	2.04	3.54	6.32	3.45	7.80	2.96	54.79
1900,	4.11	2.06	4.35	5.30	3.40	2.38	5.58	2.64	6.94	2.24	3.30	3.53	45.83
1901,	4.27	2.32	2.01	0.76	5.19	7.39	5.01	0.81	9.12	8.90	1.86	1.99	49.63
1902,	2.21	7.30	2.70	6.46	3.79	3.09	1.51	6.08	3.42	6.29	5.25	7.76	55.86
1903,	1.58	6.83	3.84	4.61	4.74	4.57	0.29	7.35	5.07	5.97	3.69	7.16	55.70
1904,	1.21	3.53	3.11	2.52	2.38	3.49	2.79	2.50	7.99	13.01	5.09	5.80	53.42
1905,	2.70	2.07	2.67	2.14	4.02	2.83	1.83	1.83	4.23	4.96	4.32	2.99	36.59
1906,	2.28	3.39	3.04	2.04	4.28	4.38	4.75	3.20	6.10	3.95	1.93	3.02	41.90
1907,	1.50	3.71	3.44	2.55	3.29	2.22	4.50	3.44	6.42	2.79	6.85	4.95	40.45
Average,	3.13	3.73	3.17	3.66	4.52	3.41	3.86	3.33	6.39	5.35	4.04	4.10	51.52
Normal for this section	3.74	3.66	3.82	3.64	3.77	3.68	4.02	3.80	4.92	4.93	3.94	3.45	47.37

* Ten months only.

Monthly Maximum and Minimum Means of Temperature Since 1896.

YEAR.	November.		December.		January.		February.		March.		April.		May.		June.		July.		August.		September.		October.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1896, ...	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	77.4	56.9	85.3	65.4	84.5	62.7	75.2	54.4	60.9	42.9
1897, ...	58.5	39.0	40.9	21.4	37.2	21.6	39.6	24.6	48.8	31.9	.....	.....	71.7	50.8	77.6	55.5	84.3	65.6	82.5	58.7	78.4	54.2	68.1	44.7
1898, ...	54.0	35.4	42.5	26.8	40.2	25.8	42.1	23.6	55.5	35.2	59.3	37.8	69.6	49.2	83.4	58.5	87.0	65.0	84.3	65.4	80.9	56.9	66.7	46.9
1899, ...	52.2	33.5	40.0	25.3	39.0	20.5	33.4	17.2	47.2	30.8	62.3	37.5	75.2	48.7	84.4	60.5	85.8	64.0	81.6	63.1	75.5	53.7	66.7	47.4
1900, ...	52.5	34.8	45.1	27.2	40.9	23.5	40.6	21.8	45.5	25.8	61.8	40.0	75.6	48.4	81.8	60.2	88.4	64.6	86.8	66.8	81.6	59.3	67.8	51.2
1901, ...	55.9	38.9	41.7	24.4	37.6	24.0	32.2	17.6	48.6	30.6	56.1	40.5	69.4	48.9	83.5	58.3	87.4	67.7	84.6	64.9	78.7	56.4	67.0	42.2
1902, ...	46.8	30.5	41.3	23.9	36.7	20.1	25.1	19.5	54.8	34.4	62.2	40.4	73.2	49.0	81.5	56.2	84.0	63.1	81.8	58.6	73.9	54.7	65.7	45.9
1903, ...	58.9	39.1	38.6	22.7	37.4	21.6	42.5	23.5	58.7	37.4	61.2	39.8	76.9	49.9	72.9	55.2	85.4	61.2	77.8	59.0	76.2	54.1	65.1	46.5
1904, ...	49.9	29.3	37.1	20.3	31.0	13.2	34.1	15.0	45.8	28.0	57.2	35.5	77.4	50.7	80.7	56.9	82.3	61.7	82.0	59.7	76.6	53.1	63.8	39.3
1905, ...	49.1	39.7	34.4	17.2	34.7	18.6	32.2	12.9	57.3	29.2	69.7	38.6	72.7	49.7	78.3	57.3	85.6	63.7	80.0	60.9	72.7	52.7	66.0	43.6
1906, ...	52.5	30.5	44.6	27.4	44.1	27.2	41.8	18.5	41.3	25.8	64.4	38.8	74.4	48.7	81.9	59.8	83.6	63.0	83.4	65.5	79.8	57.4	63.0	44.9
1907, ...	52.1	35.0	41.4	23.0	39.8	21.5	32.4	11.4	51.5	29.3	56.4	32.9	66.5	44.6	75.7	52.6	84.6	61.5	81.7	58.7	76.9	56.6	61.7	37.6

EXPERIMENTS FOR THE BENEFIT OF THE PEACH INDUSTRY.

In 1905 a general survey of the prominent peach sections in the State was made by Doctor Warren, and this was followed by Bulletin No. 197, "Suggestions for the Renewal of the Peach Industry in New Jersey." To continue this preliminary work and to make a thorough study of the peach problems, it was considered desirable to have experimental orchards located in the peach growing sections. This would bring the experiments under much the same soil and weather conditions as the orchards of the fruit growers, and make the results of more practical value.

The sandy soils in the southern portion of the state are distinctly different from those of Hunterdon County and the moisture and temperature conditions are also much different. Thus to get results that would be of certain value to the whole state it was very desirable to locate an orchard in Hunterdon County and another in southern Jersey.

Land was secured for a part of the work upon the farm of Ex-Governor Foster M. Voorhees, at High Bridge, and an orchard of 1,032 trees was set in the spring of 1906. In the spring of 1907 another lot of land was made available to the station upon the grounds of the Training School, at Vineland, where 675 trees were put out. The station has full control of these orchards to carry out any experiments that may be planned.

Important features of the work are, the determination of expense and what may be expected in the way of returns from a peach orchard carried on under up-to-date methods; the investigation and demonstration of the best methods of fertilization, pruning, spraying, and general management of the orchard; and the picking, shipping and marketing of the fruit. Such an experiment will necessarily cover practically all of the peach problems of the state.

The cultivation and general management of each orchard is made to conform to a certain degree to the general practice of the section in which it is located. For example, no attempt is being made to grow market garden crops between the trees at High Bridge, though this is being done at Vineland. The plan is to

follow lines of treatment that are of practical value and can be adopted by the peach growers of each section.

The general care and cultivation of each orchard is under the supervision of the foreman at each place. He has charge of the plowing, harrowing, cultivating and the general management of the crops grown between the trees and other duties connected with the orchard. He keeps an account of all labor and expense incurred under his direction.

It is impossible for the Horticulturist to be present at the orchard except when special features of the work such as pruning, spraying, fertilization, etc., are under way; therefore, the cultural condition and general appearance of the orchard necessarily depends upon the foreman.

Good management of teams and men is a very important matter in all agricultural operations and especially so in orchard work. A careless teamster can do irreparable damage to a young orchard in a very short time. Poor management will also greatly increase the expense.

The charges for labor are made according to the prices and hours prevailing in the section in which the orchard is located.

For the year 1906, at High Bridge, the charge for a team and man for a day of 10 hours is $3.50; and for a laborer, $1.50. For the season 1907, the charge for a team and man is $4.00, and for a laborer, $1.50.

At Vineland the charge for a team and man is $4.00 for a day of 9 hours, and for a laborer $1.50 a day.

I wish to thank Ex-Governor Foster M. Voorhees and Professor E. R. Johnstone for the interest they have taken in the experiments. Their interest has indirectly assisted me to a great degree. Mr. C. M. Veale has managed the general work in connection with the orchard at Vineland in a very acceptable manner, and has been of much assistance in other features of the work.

The outlines of the various experiments, cost of trees, expenses of setting, pruning, spraying, fertilization and other details of the work may be found in the report upon each orchard.

Peach Experiments at High Bridge.

In the spring of 1906 an orchard of 1032 trees was set upon the farm of Ex-Governor Foster M. Voorhees, at High Bridge. The experiments were planned and started by Doctor Warren and the report of the first season's work is taken from his notes. An account of all labor in the care and management of the orchard was kept and presented to me December 29th, by Mr. E. L. Rogers, the farm foreman. The cost of trees, fertilizers, freight and express upon same, and labor of setting trees, etc., was recorded by Doctor Warren.

SITE OF THE ORCHARD.

The field selected contains about 5 acres and is at the summit of a hill of sufficient elevation to insure good air drainage. The orchard is enclosed by the usual stone fences and hedgerows found in the section, but is not sheltered in any way with perhaps the exception of a small portion at the northwest corner. The land has a slight general slope toward the the east and slopes north and south somewhat from the center near the west side.

THE SOIL.

The soil is a yellowish brown loam and very stony; so much so that it required a pick to dig a hole for each tree set. This condition of the soil increases the cost of cultivation considerably as will be shown in comparison with the cultivation of the Vineland orchard. Some damage is also done to the trees by the quick "shifting" of harrows while passing over the loose stones near the trees. The extent of such injury depends in a great measure upon the care and watchfulness of the workman who is doing the harrowing.

There are a few boulders scattered through the orchard; some show above the surface, while others are completely below, and these have influenced the growth of the trees in a few cases. Wherever this occurs in any of the plots allowances will have to be made in making comparisons.

The soil is fairly uniform throughout, but there are a few distinct variations upon small areas. The soil in the northwest corner is more of a sandy loam and produces a much greater growth than the rest of the field. This section contains the varieties so it is outside the general plot work. Plot 17 is exceedingly stony; in fact it was difficult to find soil enough to put around the trees when set. Plots 6 and 12 are somewhat similar but not to the same degree.

The field chosen for this orchard experiment is by no means an example of the best peach soils in Hunterdon County. The point in view was to take a soil of medium quality and demonstrate its possibilities for peach growing.

PREVIOUS HISTORY OF THE LAND.

No records as far as known were kept as to the treatment of this field previous to its being used by the station for this orchard experiment, but it has been possible to learn in a general way about what its general previous treatment was. Two or more corn crops and one crop of buckwheat had been grown and taken off the land, with the application of but very little or no fertilizer, and it is doubtful if the field ever received liberal applications of fertilizers of any kind. The land had also become very weedy.

PLAN OF THE ORCHARD.

The greater part of the orchard consists of 22 plots, each containing 25 trees of Elberta, and each plot separated from adjoining plots by a row of Mountain Rose trees. This is expected to assist greatly in keeping the yields of the various plots separate when the trees come into bearing. A portion of the northwest section of the orchard consists of a variety test, the following kinds being represented: Belle of Georgia, Carman, Greensboro, Graves, Hiley, Maule's Early, Niagara, Guinn, Ray, Waddell and Willetts. East of these varieties and north of the plots are 126 Elbertas which are to be used for pruning experiments, and general investigations outside of the plot work.

All of the trees are set 15 feet apart each way. It is not recommended that all growers will set at this distance. Such close planting requires proper heading in and a careful thinning of the branches. If this is not properly attended to, the fruit will lack color, and the conditions will also be very favorable to the attack of brown rot.

At least 25 trees to a plot was considered necessary for comparative results, as differences due to individuality are often considerable.

PLAN OF THE EXPERIMENT.

The general plan is a comparison of various fertilizer combinations and the effects of cover cropping. All the plots were in duplicate at the beginning of the experiment, for example, 1 and 7, 6 and 12, 16 and 21, etc., but the past season one plot of each form of treatment was cover-cropped and this is to be continued. The various fertilizer applications, per acre, are as follows:

Plots 1 and 7—5 tons of stable manure.

Plots 2 and 8—150 lbs. nitrate of soda, 150 lbs. muriate of potash, 100 lbs. ground bone, 200 lbs. acid phosphate.

Plots 3 and 9—100 lbs. nitrate of soda, 150 lbs. muriate of potash, 100 lbs. ground bone, 200 lbs. acid phosphate.

Plots 4 and 10—150 lbs. nitrate of soda, 150 lbs. muriate of potash, 100 lbs. ground bone, 200 lbs. acid phosphate. (Nitrate not to be applied after cover-crops are started.)

Plots 5 and 11—150 lbs. nitrate of soda, 150 lbs. muriate of potash, 100 lbs. ground bone, 200 lbs. acid phosphate.

Plots 6 and 12—150 lbs. nitrate of soda, 200 lbs. muriate of potash, 100 lbs. ground bone, 200 lbs. acid phosphate.

Plots 13 and 18—150 lbs. nitrate of soda, 150 lbs. muriate of potash, 100 lbs. ground bone, 200 lbs. acid phosphate.

Plots 14 and 19—150 lbs. nitrate of soda, 150 lbs. muriate of potash, 100 lbs. ground bone.

Plots 15 and 20—Nothing.

Plots 15 and 20—Nothing.

Plots 16 and 21—150 lbs. nitrate of soda, 150 lbs. muriate of potash, 100 lbs. ground bone, 200 lbs. acid phosphate.

Plots 17 and 22—150 lbs. nitrate of soda, 350 lbs. kainit, 100 lbs. ground bone, 200 lbs. acid phosphate.

It will be noticed that comparisons are made between different amounts of nitrate of soda, between two forms of potash and

an increased amount of potash in the form of muriate; also, upon plots 4 and 10 the effect will be noted of discontinuing the application of nitrate after the cover-crop work is begun. Plots 7 to 12 and 13 to 17 are the ones to be cover-cropped. Plots 14 and 19 receive no acid phosphate and the fertilizers applied furnish potash and phosphoric acid in about the same ratio as was shown by the tree analyses, previously studied by the department.

Different systems of pruning at the time of planting, dipping the trees in lime sulfur, exposure of trees before setting and a comparison of June buds with one-year-old trees have been tested, and the results published in Bulletin No. 197.

A test of a number of vareties is also under way, as stated under a previous heading.

EXPLANATION OF PLAN NO. I.

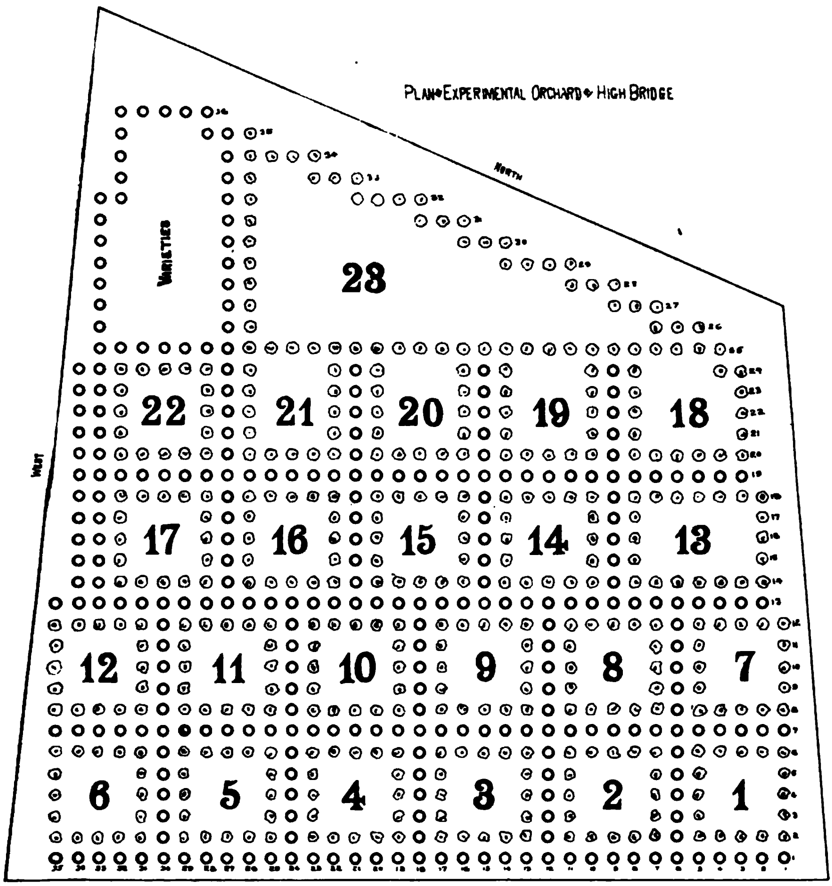
Fig. ●● represents trees of the variety Elberta. Each plot contains 25 trees with the exception of Plot 23.

Fig o represents trees of Mountain Rose between the plots, and various other varieties at the northwest corner.

The small numerals at the base of the plan designate the number of each tree, while the figures at the side and top designate the number of each row. The east tree in each row is tree number 1 of that row, and the south row is row number 1.

Rows 1, 7, 13 and 19 are Mountain Rose trees, and also the trees separating the plots north and south.

Row	14,	trees	33 and 34 are Ray.
"	15,	"	33 and 34 are Maule's Early.
"	16,	"	33 and 34 are Waddell.
"	17,	"	33 and 34 are Guinn.
"	18,	"	33 and 34 are Belle of Georgia.
"	19,	"	33 and 34 are Carman.
"	20,	"	33 and 34 are Greensboro.
"	21,	"	33 and 34 are Hiley.
"	22,	"	33 and 34 are Willetts.
"	23,	"	33 and 34 are Graves.
"	24,	"	33 and 34 are Graves.
"	25,	"	27 to 33 (inclusive) are Graves.



PLAN • EXPERIMENTAL ORCHARD • HIGH BRIDGE
NORTH
WEST
VARIETIES
28
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

Row 26,	trees 27 to 33	(inclusive)	are Willetts.
" 27,	" 27 to 33	"	are Hiley.
" 28,	" 27 to 33	"	are Greensboro.
" 29,	" 27 to 33	"	are Carman.
" 30,	" 27 to 33	"	are Belle of Georgia.
" 31,	" 27 to 33	"	are Guinn.
" 32,	" 27 to 33	"	are Waddell.
" 33,	" 27 to 32	"	are Maule's Early.
" 34,	" 27 to 32	"	are Niagara.
" 35,	" 27 to 32	"	are Ray.
" 36,	" 28 to 32	"	are Ray.

PREPARATION OF THE LAND FOR THE ORCHARD.

The land was plowed in the fall of 1905, but the work was rather poorly done. In the spring of 1906 it was thoroughly harrowed twice before furrowing out for the trees.

GRADE, QUALITY AND COST OF TREES.

The Elbertas were good trees of medium grade. They would be described by nurserymen as "First Class, Medium, 4–5 ft., caliper ½–⅝ inches." Many of the trees were quite seriously injured by borers.

The Mountain Rose trees were slightly larger than the Elbertas and were also somewhat damaged by borers.

The Belle of Georgia, Carman, Hiley and Greensboro were of about the same grade and quality as the Elbertas.

The Guinn, Waddell and Maule's Early were June buds, 6 inches to 1 foot; the Waddell were rather poorer than the others.

The Willetts were slender whips.

The Graves were good trees of grade "First Class, caliper ¾."

The Niagara and Ray were large trees and would grade as "First Class XX.," or as "Extra, 5–7 ft."

The grade of these trees is described, as comparisons of growth and value of size will appear later.

The cost of the Elbertas was $6.00 per 100, and of the Mountain Rose, $7.00 per 100.

TREATMENT OF TREES BEFORE PLANTING.

The trees were heeled in upon their arrival to keep the roots moist until the land had been put in condition to receive them, and just before they were set all injured roots were cut smooth and the tops cut back to about 2-inch stubs wherever possible, but many had to be pruned to 18–24-inch whips. The roots of all trees were dipped in water, except where a test of exposure was made. A test was also made of dipping the trees in lime sulfur, from which no injurious effects were detected.

COST OF SETTING.

The field was furrowed out with a plow where the trees were to be set, but it was necessary to use a pick in every case to make a hole of the proper depth. All of the holes were dug previous to the beginning of the work of setting. The entire labor of planting, etc., amounted to that of two men for eight days. The division of the orchard into plots, with a row of Mountain Rose between each, and the minor experiments undertaken, increase the labor considerably. Doctor Warren estimates that two men can prune, dig holes and set 150 trees a day under the conditions of the field selected at High Bridge when no time is given to experiments. Upon the sandy soils of southern Jersey it is no difficult matter to put out 400 trees in a day of nine hours, with two men to set and a boy to drop the trees. In fact, it was found possible to do considerably better than this, as will be shown later in the report upon the experiment orchard at Vineland. This is an illustration of how soil conditions may increase the cost of orchard work.

SUBSEQUENT CARE OF THE ORCHARD.

The orchard was harrowed May 22 and planted to corn May 24. Four rows of corn were planted between each two rows of trees. The corn and trees were then cultivated whenever it

was needed, according to the judgment of the foreman. When mature the corn was cut and handled in the usual manner and a record of yield kept. The crop was injured by cutworms to quite an extent in one portion of the orchard.

COST OF TREES, FERTILIZER, ETC.

Trees and fertilizer, including freight and express,	$137 36
Carting and heeling in trees,	5 40
Labor, mixing and applying fertilizer and other work,	18 00
Labor, setting and pruning trees, etc.,	24 08
Lime sulfur,	25
	$185 09

EXPENSES OF ORCHARD AFTER SETTING.

(*Account of Mr. E. L. Rogers.*)

Apr.	18–19.	Harrowing,	$3 50
"	20.	Furrowing out,	70
May	22.	Harrowing,	3 50
"	23.	Marking out,	3 50
"	23–25.	Planting corn,	3 75
		Seed corn,	1 25
June	15.	Cultivating,	3 50
"	20.	Banking trees,	1 88
"	28–29.	Cultivating,	10 49
Sept.	21–24.	Cutting corn,	6 72
		Tar rope,	1 50
"	26.	Husking,	3 00
		Carting corn,	2 00
Nov.	28.	Carting corn,	5 00
			$50 29

Receipts.

117 bu. No. 1 corn, @ $0.65 per 100 lbs.,	$53 24
21 " No. 2 " @ $0.10 " bu.,	2 10
363 bundles of stalks,	14 52
	$69 86
	50 29
Balance over cost of cultivation,	$19 57

Cost per tree at end of first year, $0.16.

Net cost of orchard at the end of first season, $33.10 per acre.

SEASON OF 1907.

My work with this experiment really began in the spring of 1907. In order to determine in a definite manner the growth made by the trees upon the various plots, five trees were selected in each plot that represented as near as could be estimated the average annual growth made by that plot, and carefully measured the growth made by each of the five trees. It should not be inferred, however, that the results obtained accurately show the influence of the various fertilizer treatments; they are of considerable value for other comparisons, however. Slight differences in quality and grade of trees, minor variations in soil and other factors, have undoubtedly affected the annual growth of individual trees. A careful study of the orchard the past summer has enabled me to detect these variations due to other causes, and these can be more accurately estimated when the measurements are taken in the spring of 1908.

AMOUNT OF ANNUAL GROWTH MADE IN SUMMER OF 1906.

Plot.	Tree.	Number of Branches.	Longest. (Inches.)	Shortest. (Inches.)	Total Growth. (Inches.)
I.	1	14.0	18.0	3.0	136.0
	2	26.0	33.0	4.0	293.0
	3	16.0	22.0	2.0	183.0
	4	16.0	18.0	3.0	153.0
	5	15.0	23.0	5.0	251.0
Av. of Plot,	....	17.4	22.8	3.4	203.2
VII.	1	22.0	28.0	4.0	290.0
	2	24.0	29.0	3.0	265.0
	3	22.0	25.0	2.0	257.0
	4	19.0	30.0	4.0	228.0
	5	19.0	15.0	3.0	158.0
Av. of Plot,	....	21.2	25.4	3.2	239.6
II.	1	34.0	32.0	2.0	395.0
	2	19.0	26.0	3.0	238.0
	3	30.0	30.0	2.0	378.0
	4	27.0	29.0	4.0	240.0
	5	12.0	34.0	4.0	170.0
Av. of Plot,	....	24.4	30.2	3.0	284.2

Plot.	Tree.	Number of Branches.	Longest. (Inches.)	Shortest. (Inches.)	Total Growth. (Inches.)
VIII.	1	15.0	20.0	5.0	180.0
	2	36.0	32.0	2.0	404.0
	3	16.0	28.0	2.0	209.0
	4	25.0	33.0	4.0	337.0
	5	37.0	32.0	2.0	495.0
Av. of Plot,	....	25.8	29.0	3.0	325.0
III.	1	11.0	27.0	7.0	169.0
	2	31.0	27.0	3.0	397.0
	3	21.0	27.0	3.0	220.0
	4	20.0	29.0	2.0	228.0
	5	18.0	28.0	3.0	260.0
Av. of Plot,	....	20.2	27.6	3.6	254.8
IX.	1	12.0	23.0	4.0	155.0
	2	17.0	22.0	4.0	177.0
	3	16.0	16.0	3.0	141.0
	4	17.0	20.0	3.0	145.0
	5	21.0	26.0	2.0	195.0
Av. of Plot,	....	16.6	21.4	3.2	162.6
IV.	1	37.0	30.0	2.0	395.0
	2	19.0	23.0	2.0	224.0
	3	24.0	32.0	4.0	315.0
	4	27.0	31.0	2.0	356.0
	5	24.0	34.0	2.0	301.0
Av. of Plot,	....	26.2	30.0	2.4	318.2
X.	1	23.0	25.0	2.0	261.0
	2	25.0	28.0	2.0	269.0
	3	11.0	22.0	4.0	140.0
	4	17.0	22.0	5.0	192.0
	5	17.0	22.0	3.0	223.0
Av. of Plot,	....	18.6	23.8	3.2	217.0
V.	1	26.0	28.0	2.0	292.0
	2	27.0	36.0	3.0	382.0
	3	23.0	36.0	2.0	295.0
	4	17.0	30.0	4.0	205.0
	5	27.0	32.0	2.0	368.0
Av. of Plot,	....	24.0	32.6	2.6	308.4
XI.	1	27.0	37.0	4.0	291.0
	2	22.0	36.0	6.0	296.0
	3	16.0	22.0	3.0	175.0
	4	8.0	16.0	6.0	94.0
	5	10.0	24.0	7.0	143.0
Av. of Plot,	....	16.6	27.0	5.2	199.8

Plot.	Tree.	Number of Branches.	Longest. (Inches.)	Shortest. (Inches.)	Total Growth. (Inches.)
VI.	1	9.0	20.0	3.0	97.0
	2	9.0	12.0	2.0	67.0
	3	11.0	20.0	2.0	121.0
	4	8.0	8.0	2.0	38.0
	5	13.0	16.0	2.0	108.0
Av. of Plot,	....	10.0	15.2	2.2	86.2
XII.	1	11.0	19.0	3.0	126.0
	2	8.0	17.0	2.0	75.0
	3	7.0	10.0	2.0	32.0
	4	12.0	19.0	2.0	82.0
	5	7.0	6.0	2.0	34.0
Av. of Plot,	....	9.0	14.2	2.2	69.8
XIII.	1	20.0	30.0	4.0	269.0
	2	17.0	21.0	5.0	182.0
	3	30.0	28.0	2.0	349.0
	4	34.0	27.0	4.0	383.0
	5	26.0	33.0	2.0	277.0
Av. of Plot,	....	25.4	27.8	3.4	292.0
XVIII.	1	14.0	22.0	5.0	174.0
	2	18.0	30.0	3.0	270.0
	3	8.0	19.0	3.0	92.0
	4	20.0	27.0	2.0	198.0
	5	13.0	17.0	2.0	124.0
Av. of Plot,	....	14.6	25.0	3.0	171.6
XIV.	1	20.0	28.0	4.0	270.0
	2	37.0	32.0	4.0	464.0
	3	28.0	26.0	3.0	338.0
	4	14.0	26.0	4.0	190.0
	5	8.0	23.0	6.0	116.0
Av. of Plot,	....	21.4	27.0	4.2	275.6
XIX.	1	21.0	38.0	3.0	304.0
	2	30.0	33.0	2.0	440.0
	3	26.0	29.0	3.0	338.0
	4	35.0	34.0	3.0	374.0
	5	33.0	30.0	3.0	464.0
Av. of Plot,	....	29.0	32.8	2.8	384.0
XV.	1	32.0	25.0	2.0	367.0
	2	28.0	25.0	2.0	294.0
	3	28.0	28.0	3.0	364.0
	4	37.0	23.0	3.0	326.0
	5	19.0	24.0	5.0	230.0
Av. of Plot,	....	28.8	25.0	3.0	316.2

Plot.	Tree.	Number of Branches.	Longest. (Inches.)	Shortest. (Inches.)	Total Growth. (Inches.)
XX.	1	24.0	32.0	6.0	361.0
	2	29.0	28.0	3.0	331.0
	3	46.0	37.0	3.0	529.0
	4	17.0	27.0	2.0	223.0
	5	28.0	25.0	2.0	285.0
Av. of Plot,	....	28.8	29.8	3.2	345.8
XVI.	1	30.0	35.0	2.0	342.0
	2	30.0	34.0	2.0	387.0
	3	22.0	30.0	2.0	294.0
	4	33.0	33.0	2.0	424.0
	5	24.0	28.0	2.0	321.0
Av. of Plot,	....	27.8	32.4	2.0	353.6
XXI.	1	35.0	29.0	2.0	433.0
	2	37.0	25.0	2.0	333.0
	3	48.0	30.0	5.0	610.0
	4	23.0	29.0	3.0	258.0
	5	20.0	29.0	4.0	275.0
Av. of Plot,	....	32.6	28.4	3.2	380.2
XVII.	1	8.0	16.0	9.0	93.0
	2	10.0	13.0	3.0	87.0
	3	16.0	21.0	2.0	122.0
	4	6.0	12.0	2.0	44.0
	5	18.0	25.0	4.0	190.0
Av. of Plot,	....	11.6	17.4	4.0	107.2
XXII.	1	36.0	27.0	2.0	376.0
	2	25.0	27.0	2.0	347.0
	3	42.0	34.0	2.0	540.0
	4	28.0	35.0	2.0	309.0
	5	30.0	25.0	2.0	294.0
Av. of Plot,	....	32.2	29.6	2.0	373.2

It will be noticed that plots VI., XII. and XVII. show a very poor growth in comparison with the rest of the orchard. These were not planted to corn in 1906 and became much more weedy after cultivation ceased. These plots are also upon the very stony soil and will have to be compared with each other.

The stable manure plots did not make as good a growth as those receiving nitrate, muriate, bone and acid phosphate. This

was to be expected, as the manure would not be as quickly available to the trees.

Plots XV. and XX., to which nothing was applied, made a better growth than most of the plots upon the south side of the orchard. The soil is of a different character, and numbers XV. and XX. should be compared with XIX., XXI. and XXII. This emphasizes the fact that a proper selection of soil is a very important point in starting a peach orchard. Far too many orchards are set out without due consideration of this matter.

The annual growth of some of the Elberta trees, north of the general plot work, was measured in connection with the beginning of a pruning test, and these have been averaged with those measured upon the plots. The average annual growth of the 125 trees measured is 282.6 inches. The largest amount of annual growth made by any individual tree measured was 872 inches. It will be interesting to note what such a tree will do when it comes into bearing.

Many of the branches upon the trees had made a growth of from twenty-five to thirty inches; the longest upon any of the Elbertas measured was forty-eight inches, and this was upon the tree which made a total growth of 872 inches.

The Elbertas throughout the orchard made a good growth, but it would be exceeded by trees upon a better soil, or upon a similar soil having better previous treatment.

The Mountain Rose trees made a somewhat better growth than the Elbertas, but the former variety is generally a more free grower. The average annual growth made by the seventy-nine trees measured was 342.7 inches, and the best growth made by any individual tree was 850 inches, a trifle less than the best Elberta. This amount of difference would probably not be noticed by an observation of the two trees, as they would appear practically equal.

Two trees each of a number of the varieties were measured to make a comparison of their vigor and to note the influence of the difference in the grade of the trees.

Variety.	Tree No. 1.	Notes.	Tree No. 2.	Notes.
Willetts, ...	186	An average tree,..	364	Largest of all.
Graves, ...	507	" " " ..	474	An average tree.
Carman, ...	474	" " " ..	451	" " "
Ray, ...	478	" " " ..	484	" " "
Belle of Ga.,......	581	" " " ..	677	A large tree.
Hiley, ...	341	A small tree,.....	825	" " "

The largest Willetts made less growth than any of the trees of average size of the other varieties. This variety appears to make a more slender growth, and the trees were also of a lighter grade at the beginning of the experiment than Graves, Carman, etc. The varieties Ray, Carman, Graves and Belle of Georgia are quite uniform. The Hiley trees made an exceptionally strong growth. One of the small trees is not up to the average of the other varieties, but the larger trees have made considerably more growth. The tree making a growth of 825 inches is not the only one of this size. All of the varieties mentioned had a few blossom buds, with the exception of Willetts and Graves, but, of course, did not develop fruit.

PRUNING AND SPRAYING.

The pruning was done in early spring, as soon as the measurements were taken. The trees were severely headed back and some branches trimmed out.

A block of the Elbertas north of the plots was selected and alternate trees in the rows headed back. The tops of the trees not headed back were thinned wherever it was necessary. Measurements of the annual growth of the trees were made before and after pruning. It is planned to make a comparison of these two methods of pruning upon the annual growth, yield and quality of the fruit, and the length of life of the trees.

The borers were taken out just previous to the pruning of the trees. Only a few large borers were found, but quite a good many very small ones, usually about ¼ inch in length. It has been observed that nursery trees may contain very small larvæ

of the peach borer and these often work down to the side roots. There was some doubt at first as to whether these were the larvæ of the true peach borer, but this was determined by Dr. Smith who examined specimens which were brought directly from the orchard. From the nature of the injury to the trees and the presence of the young borers, it is inferred that some of these small larvæ were in the trees when set and that these matured late in the season of 1906 and produced a late brood. Last spring a few of these small borers were found in some one year old nursery trees, and it is likely they would be often overlooked.

The orchard was sprayed with lime sulfur and salt under the direction of Mr. Rogers, and the total expense of the work was $5.51, including the cost of materials. The severe heading back of the trees considerably reduced the amount of surface to be sprayed.

APPLICATION AND COST OF FERTILIZERS.

The fertilizer was applied to the various plots upon May 7 before the land was plowed.

The cost per acre of the various fertilizer treatments may be of interest. The price paid per ton for the different materials was as follows:

Stable Manure,	$1 50
Nitrate of Soda,	60 00
Muriate of Potash,	40 00
Sulfate of Potash,	50 00
Kainit,	12 00
Bone,	28 00
Acid Phosphate,	13 00

The freight and cartage upon the fertilizer, also the cost of mixing and applying, amounts to $0.0022 per pound, and it is charged against the plots at this rate in the following table. This does not include the stable manure which was made upon the farm.

Fig. 1. View in orchard at High Bridge, taken after it had been plowed and harrowed, which illustrates the stony character of the soil.

TABLE.

No.	Treatment (Pounds per acre).	Cost.
1.	Stable manure, 5 tons, including carting and spreading, ...	$10 15
2.	Nitrate, 150; muriate, 150; acid phosphate, 200; bone, 100, ...	11 52
3.	Nitrate, 100; muriate, 150; acid phosphate, 200; bone, 100, ...	9 91
4.	Same as No. 2 at present, ...	11 52
5.	" " No. 2 " "	11 52
6.	Nitrate, 150; muriate, 200; acid phosphate, 200; bone, 100, ...	12 63
7.	Nitrate, 150; sulfate, 150; acid phosphate, 200; bone, 100, ...	12 27
8.	Nitrate, 150; muriate, 150; bone, 100, ...	9 78
9.	Nothing, ...	0 00
10.	Same as No. 7, ...	12 27
11.	Nitrate, 150; kainit, 600; bone, 100; acid phosphate, 200, ...	12 81

SUBSEQUENT TREATMENT OF THE ORCHARD.

The orchard was thoroughly plowed and harrowed in May, and upon June 7 was again planted to corn. Three rows were planted between each two rows of trees.

The land was badly infested with weed seed from previous years, especially with charlock, or wild turnip, as it is called by some. This was not properly attended to by the foreman during July, and severely checked the growth of the corn; dry weather also made the matter worse. The weeds were pulled and cut down the last of July, and the first of August furrows were plowed to each side of the corn rows and to the rows of trees. The expense of clearing the orchard of weeds was greatly increased by not being done at the proper time. The grain crop has to be harvested in July, but if you are attempting to grow peaches successfully, a day spent in harrowing your orchard when it first needs it or even the hiring of an extra team for the work will be a great saving in final expense.

SUMMER PRUNING.

The peach will make a strong growth the second summer after planting if set upon suitable soil and properly fertilized, and the new growth will be especially vigorous and thick if the tree received a severe heading back in the spring. By the latter

part of June the leading shoots will have made a growth of from 25 to 30 inches, and if not checked will continue to make a straight growth of from 45 to 55 inches. Such shoots, if pinched back in June, will throw out strong side branches and make a more compact, well-balanced tree.

No emphatic rule can be stated as to what length the shoots should be allowed to grow before being pinched back, because there are various ideals of form and each tree is a problem in itself. Some branches should be allowed to grow longer than others to balance the tree. The grower should have his ideal in mind and pinch back the strong shoots when they have nearly reached a point where he wishes side branches to be formed; however, it will not do to wait until the later part of the summer before doing this work as side branches started so late will be weak and liable to winter kill. Upon rapid growing young peach trees there are likely to be too many strong shoots making up the head, and these should be thinned out at the same time the "pinching back" is done. This gives more light and room to the selected branches and causes a stronger growth in the directions desired; but trees that are not making a strong growth the second summer should not be pinched back, as it may serve to still further check them.

EXPENSES OF SECOND SEASON AT HIGH BRIDGE.

Pruning, taking out borers, resetting a few trees,	$4 35
Thirty-seven extra trees,	3 25
Spraying,	5 51
Fertilization,	53 24
Plowing and harrowing,	26 00
Planting corn,	4 00
Cultivation,	26 75
Labor, weeding, etc.,	7 66
Summer pruning,	2 70
Cover crop for certain plots,	7 00
	$140 46

Expense per acre for the second season,	$28 09
Cost per tree at the end of second year,	30

Late planting, lack of cultivation at the proper time, and dry weather would have resulted in a light crop of corn between the

trees, but sheep were allowed to break into the orchard and destroy the whole crop the latter part of the summer. It would be rather difficult to satisfactorily estimate the value of the crop destroyed. The whole matter of general care and cultivation was disappointing. It distinctly points out in dollars and cents, however, the cost of poor management in the cultivation of an orchard and crops. This is the cause of failure today upon many farms. The man who is a week or two late in each operation of his work is losing money.

Peach Experiments at Vineland.

The experiment orchard at Vineland is located upon land owned by the Training School. The field chosen for the site of the orchard is at about the same level as the land surrounding it. There is a slight general slope to the north and a slight depression across the orchard from southwest to northeast. It is partially protected at the northwest corner by an oak grove, and a hedgerow of mixed deciduous trees a short distance from the orchard upon the west may provide some shelter also.

An old pear orchard previously occupied part of the land before it was cleared up for the setting of the peach orchard. Nothing had been done in the way of fertilization or cultivation of either the pear orchard or the land surrounding it for a number of years previous to 1906. The pear orchard probably received somewhat better care than the surrounding land some years ago, and the soil under the trees would contain more organic matter.

In 1906, the whole field was plowed and planted to cowpeas. At that time 300 pounds per acre of the following fertilizer mixture was applied to the land:

Nitrate,	155	lbs.
Tankage,	360	"
Dried fish,	180	"
Muriate,	500	"
Steamed bone,	180	"
Acid phosphate,	1,025	"
	2,400	"

Three hundred pounds per acre of this mixture is equivalent to:

Nitrate,	19.4 lbs.
Tankage,	45.0 "
Dried fish,	22.5 "
Muriate,	62.5 "
Steamed bone,	22.5 "
Acid phosphate,	128.1 "

The cowpeas were cut green and were followed by crimson clover as a cover-crop. The old pear trees were pulled out in the winter of 1906–1907.

SOIL.

The soil is probably what is known as Norfolk sand. It is distinctly different from that of the orchard at High Bridge and is very easy to work. Samples were taken from different parts of the field for analysis, the results of which will be published later. The soil is quite uniform throughout the orchard, with the exception of a narrow strip upon the south side which is slightly gravelly. The section previously occupied by the pear orchard also contains more organic matter than the remainder of the field.

LAYING OUT THE ORCHARD.

After the field had been plowed and harrowed early in April, the portion to be used for the orchard was measured off and eight-inch pine labels were put out upon the south and north sides to designate where the rows of trees were to be set. With two marking poles, a steady team, and a good driver, the field was rapidly and accurately furrowed out from north to south. It was not checked rowed, however, by going east and west. By going twice in a furrow it was made deep enough so that only a little shoveling was required to set a tree.

EXPLANATION OF PLAN NUMBER 2.

Fig. • represents trees of the variety Elberta as in Plan Number 1.

PLAN OF EXPERIMENTAL ORCHARD & VINELAND

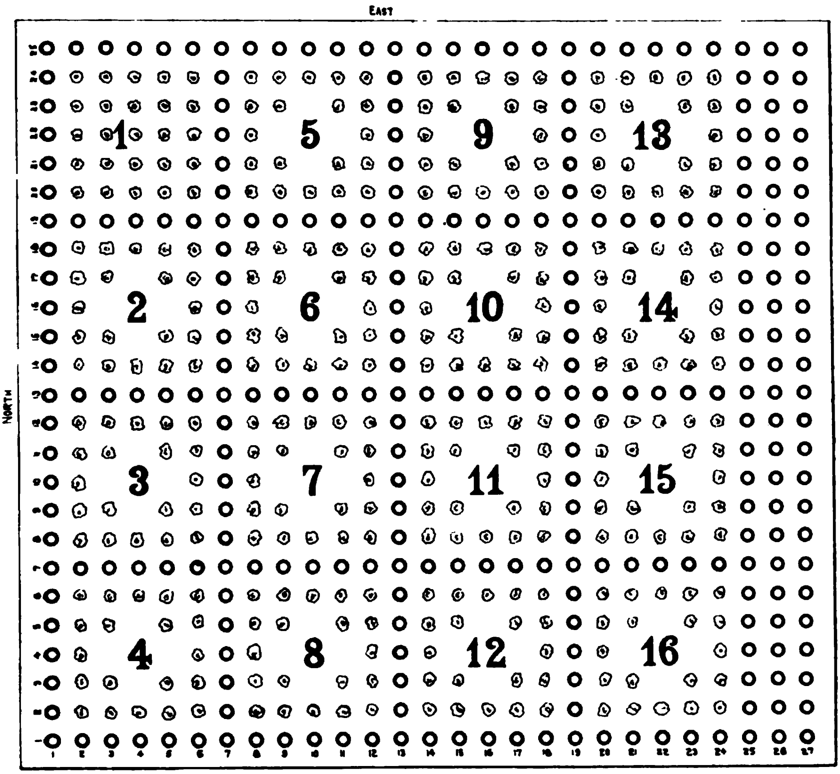


Fig. o represents trees of various varieties separating the plots, and the two rows of varieties upon the south side.

The numerals at the base of the plan designate the number of each row and the figures at the side designate the number of each tree. The west tree in each row is tree number 1 of that row, and the north row is row number 1.

Row 1 was set with Greensboro.

Row 7 was set with Waddell.

Row 13 was set with Mountain Rose.

Row 19 was set with Reeve's Favorite.

Row 25 was set with Carman.

Trees number 1, 7, 13, 19 and 25 of Rows 2 to 6 inclusive, are Greensboro.

Trees number 1, 7, 13, 19 and 25 of Rows 8 to 12 inclusive, are Mountain Rose.

Trees number 1, 7, 13, 19 and 25 of Rows 14 to 18 inclusive, are Early Crawford.

Trees number 1, 7, 13, 19 and 25 of Rows 20 to 24 inclusive, are Steven's Rareripe.

Row 26, trees 1 to 5 inclusive, are Fox Seedling.

Row 26, trees 6 to 15 inclusive, are Hiley.

Row 26, trees 16 to 20 inclusive, are Ray.

Row 26, trees 21 to 25 inclusive, are Belle of Georgia.

Row 27, trees 1 to 5 inclusive, are Frances.

Row 27, trees 6 to 15 inclusive, are Niagara.

Row 27, trees 16 to 20 inclusive, are Connecticut.

Row 27, trees 21 to 25 inclusive, are Stump.

PLAN OF THE ORCHARD.

The orchard is divided into sixteen equal plots containing twenty-five Elberta trees each, and one long plot upon the south side, which is set to various varieties. Each plot of Elbertas is separated from each adjoining plot by a row of a different variety The trees are set at the same distance and the plots are of the same size as at High Bridge. This was done so that com-

parisons can be more easily and accurately made. The following varieties are being observed and tested: Belle of Georgia, Carman, Connecticut, Early Crawford, Frances, Fox, Greensboro, Hiley, Mountain Rose, Niagara, Ray, Reeve's Favorite, Steven's Rareripe, Stump and Waddell.

PLAN OF THE EXPERIMENTS.

Special features of these experiments are the keeping of records to determine the expense and probable receipts of peach growing; various fertilizer tests, including a comparison of muriate of potash, high grade sulfate and kainit; and a comparison of two different amounts of nitrogen in the form of nitrate of soda; the determination of the effect and economic value of the various cover-crops including cow peas, crimson clover and rye; and the test of varieties previously mentioned.

FERTILIZER TREATMENT OF THE VARIOUS PLOTS.

Plot.	Nitrate. lbs.	Bone. lbs.	Acid Phosphate. lbs.	Muriate. lbs.	Sulfate. lbs.	Kainit. lbs.
1, ...	...	100	200	150	...	...
2, ...	100	100	200	150	...	...
3, ...	150	100	200	150	...	...
5, ...	...	100	200	...	150	...
6, ...	100	100	200	...	150	...
7, ...	150	100	200	...	150	...
9, ...	...	100	200	...	...	600
10, ...	100	100	200	...	...	600
11, ...	150	100	200	...	...	600
13, ...	150	100	200	...	150	...
14, ...	150	100	200	...	150	...
4, 8, 12, 15, 16,....	...	100	200	...	150	...

Plots 4, 8, 12, 15 and 16 are to be cover-cropped. The variety plot is fertilized the same as plots 13 and 14.

GRADE AND QUALITY OF THE TREES.

All of the trees were of good quality and free from borers. Trees that would caliper ⅝"–¾" were ordered and secured in

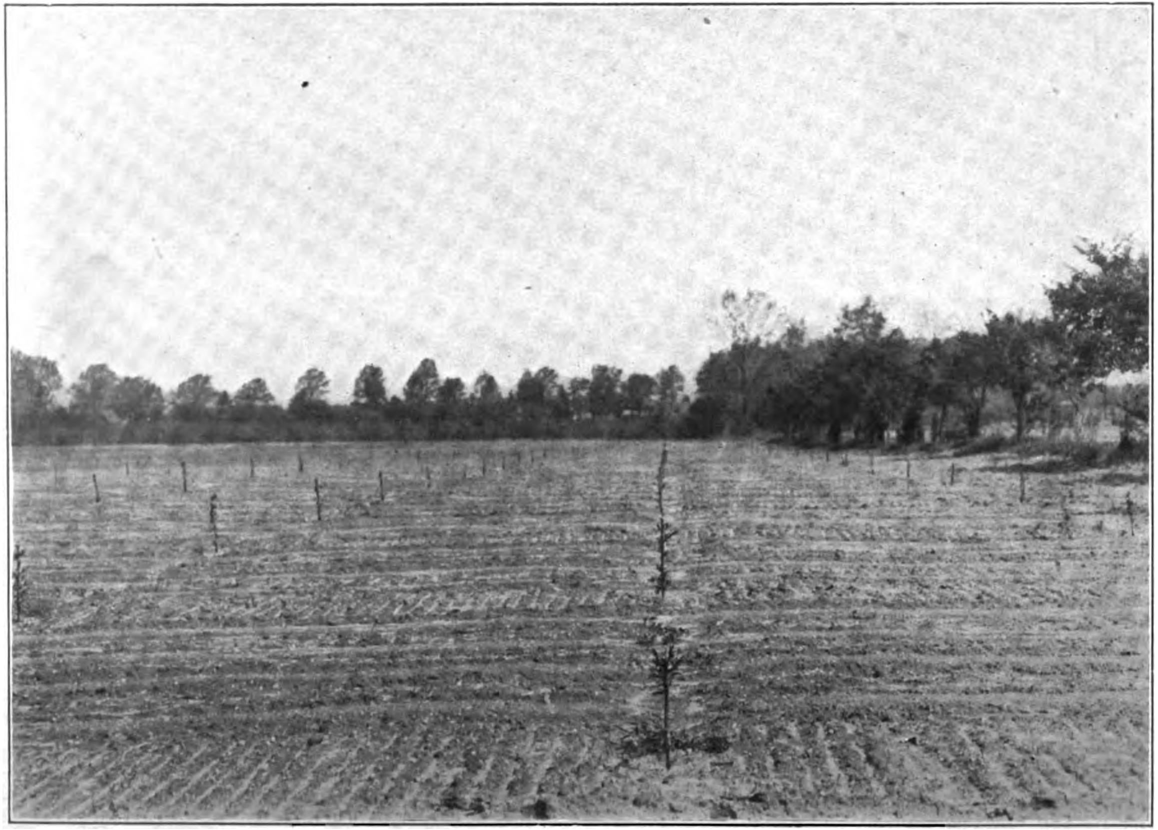


Fig. 2. View in orchard at Vineland after early sweet corn had been planted between the rows of trees. Compare with Fig. 1.

all but two varieties. The order was sent in too late to get the best grades of Waddell and Steven's Rareripe. The cost of the trees was $7 per 100, with the exception of the last two varieties mentioned which were $6 per 100. The Elbertas were nice trees and nearly all would caliper ¾-inch, and some exceeded this. The Greensboro trees were slightly smaller than the Elbertas in caliper. The Reeve's Favorite were very compact trees of the same grade as the Elbertas. Connecticut, Fox, Frances, Niagara, Ray and Belle of Georgia were also of a much similar grade. Stump, Carman, Early Crawford, Hiley, and especially the Mountain Rose, were large trees, many exceeding the ¾-inch size. The Waddell and Steven's Rareripe trees were small, and calipered ¼–½-inch.

TREATMENT OF THE TREES BEFORE PLANTING.

The trees were unpacked as soon as they were received and the roots dipped in water. This is always to be recommended as the trees near the sides of the shipping box are likely to become somewhat dried in transit, and if there is any dried "puddled" soil upon their roots they may be hindered from taking in moisture from the soil for a considerable time, unless dipped previous to setting. Trees that are set dry are much more likely to fail to start.

It is more economical to prune all the trees before beginning to set and it is necessary if the trees are to be dipped in lime sulfur in the most practical manner. The trees for the Vineland orchard were all cut back to about 18 inches; any injuries to the larger roots were cut smooth and any roots much exceeding six inches were cut back. All of the trees were dipped to the roots in lime sulfur. It takes only a very small amount of the liquid to dip from 500 to 600 trees, but it is more convenient to have at least two-thirds of a barrel of liquid, and a barrel gives one plenty of room to do the dipping. At Vineland the trees were taken directly to the site of the orchard, a barrel of water, and a barrel of lime sulfur provided; the roots of the trees dipped in water, the necessary pruning done, and the

trees heeled in to be kept moist until they were needed for setting.

SETTING THE TREES.

The site of the orchard was furrowed out from north to south after it was plowed and harrowed, as previously stated. The distances between the trees were also indicated by 8-inch labels upon the east and west sides. The outside rows consisted of variety trees and were set first. After the trees had been set upon the east and west sides it was only necessary to stretch a line across the furrows to indicate exactly where each tree should be set in each row. The line of course had to be moved each time after setting a row across from east to west. The field could have been check furrowed and the rows made straight enough for all practical purposes without a line. Slight variations would not be noticeable after one or two years' growth. However, it was more desirable to have the trees in as straight rows as possible in this case and the line method used was quite practicable. It may be that the line method followed was as economical as the making of check rows would have been. The putting in of the various varieties to separate the plots somewhat increased the time required to set the trees.

Three is a good number to make up a planting gang; two men to set, and a boy to drop the trees. The boy should have a piece of moist burlap, or any material that may be wet and wrapped about the roots of the trees, and he should not drop the trees much faster than they can be set, especially upon a bright day.

Upon a sandy soil well plowed and furrowed out, a three-man gang should be able to set 50 trees an hour. While putting in the varieties to separate the plots at Vineland the average was 40 trees per hour, and while setting the Elbertas the average was 60 an hour. It would have been possible to set 70 trees an hour after the outside rows had been set if it had been necessary to push the work.

From two to four shovelfuls of soil had to be removed from the furrow to make a hole for each tree. The tree was then held in place by one man while the other filled in top soil about

Fig. 3. Early Sweet Corn between rows of peach trees.

the roots and both assisted in firming it. After the trees were all set, the soil was filled into the furrow between the trees. This was done with a shovel near the trees, and the rest by going north and south next the trees with a cultivator, and cross harrowing. This left the soil level and well worked. As the fertilizer was applied previous to these operations it saved an extra harrowing.

FERTILIZATION.

Cost of the Various Fertilizer Treatments.

No.	Treatment (pounds per acre.)	Cost per acre.
1.	150 of muriate, 100 of bone, 200 of acid phosphate,	$7 14
2.	100 of nitrate, 100 of bone, 200 of acid phosphate, 150 of muriate,	10 46
3.	150 of nitrate, 100 of bone, 200 of acid phosphate, 150 of muriate,	12 12
5.	150 of sulfate, 100 of bone, 200 of acid phosphate,	7 89
6.	100 of nitrate, 100 of bone, 200 of acid phosphate, 150 of sulfate,	11 21
7.	150 of nitrate, 100 of bone, 200 of acid phosphate, 150 of sulfate,	12 87
9.	600 of kainit, 100 of bone, 200 of acid phosphate,	8 88
10.	600 of kainit, 100 of bone, 200 of acid phosphate, 100 of nitrate,	12 20
11.	600 of kainit, 100 of bone, 200 of acid phosphate, 150 of nitrate,	13 86
13.	Same as No. 7 at present,	12 87
14.	Same as No. 7 at present,	12 87
	Plots 4, 8, 12, 15 and 16, same as No. 5 (with addition of cover-crops later),	7 89
	Variety plot, same as No. 7,	12 87

Freight upon fertilizer, cartage, labor of mixing and spreading amounts to $0.0032 per pound and is charged at that rate in the above. The prices of the different fertilizers per ton are the same as those given in the report upon the High Bridge experiment.

CROPPING THE ORCHARD.

It was decided to crop the greater part of the orchard with sweet corn to partially pay for the expense of cultivation. The spring was very backward and the corn was not planted until May 16. Three rows were marked out with a Darnell marker between each two rows of trees, the seed dropped in the drill by hand and was covered with a corn coverer. One-half of each plot was planted to Stabler's Early and one-half to Metropolitan

corn. The labor of planting would have been somewhat reduced if a corn planter had been used.

Plot 13 was planted to snap beans upon May 16, and the variety plot to bush lima beans. Two varieties of bush limas were grown, Burpee's Quarter Century, and the Kumerle.

GROWTH OF THE TREES AND CROPS.

The trees started well and showed no injurious effects from being dipped in lime sulfur. The buds seemed to start out as quickly as upon untreated trees. For a time, about the latter part of June, the trees did not make as much growth as they should, and the leaves were light in color; but the trees were set at a good depth, and up to that time had probably not made root system enough to make use of the fertilizer applied soon after setting. The store of available plant food in the surface soil and especially near the sub-soil was evidently very small and is probably the explanation of the condition of the growth described. This is also indicated by any trees that were set wherever there had been a dead furrow such as the ones running in diagonally from the corners of the field, due to the "turns" in plowing. Such trees made a noticeably poorer growth. This point should be given more consideration, especially where the surface soil is shallow. Many of these inequalities may be avoided by proper plowing. The landside type of plow so commonly used in New Jersey is often responsible for these.

The larger grades of trees had made much the best growth up to mid-summer. Soon after the middle of July the trees began to grow rapidly, and made a good growth with a few exceptions. Plots 1, 5, and 9 made a light growth, but the soil is deficient in humus and received no nitrate. The soil of plot 13 was of the same quality but received nitrate at the rate of 150 pounds per acre, and the trees showed the effects of it the latter part of the summer.

The corn and beans remained yellow for some time after germinating, due to the unfavorable weather, and some places in the lima bean rows had to be replanted. The corn finally made

Fig. 4. Bush Lima Beans between rows of peach trees.

a good growth for the season, except on plots 1, 5, and 9. Plot 13 produced only a light crop of snap beans, and as this plot was fertilized at the rate of 150 lbs. of nitrate, 150 lbs. of sulfate of potash, 100 lbs. of bone and 200 lbs. of acid phosphate per acre, it shows the need of humus and proper cultivation.

The first picking of snap beans was made July 17, and the first of corn August 15. Dry weather as well as the unfavorable spring checked the crops.

CULTIVATION OF THE ORCHARD.

The orchard was kept well cultivated throughout the season until a cover-crop of crimson clover was sown July 17. The work was done by an Iron Age riding cultivator, and as the trees were headed low, the rows were straddled by the cultivator just the same as the corn rows between the trees. It was possible to do this until nearly mid-summer. The growing shoots finally touched the machine as it went over them but bent aside without injury. I went over the entire orchard after it was cultivated in this manner for the last time and did not find more than half a dozen broken shoots among 675 trees. Much more injury than this is often done with the ordinary cultivator; but low-headed trees are more likely to be damaged by careless workmen than high-headed trees, especially the second season. In trying to get close to the trees, the harness, whiffletree, cultivator, or harrow is liable to strike the branches that are forming the head and either break them or seriously rub off the bark. Use the shortest whiffletree possible in the orchard, and if you are working close to the trees, wind the chains of your traces with burlap or cloth; and above all, put in your steadiest team of horses and the driver who is most interested in the work. If you have not a careful man, you had better drive yourself when working about young peach trees.

COST OF PUTTING OUT ORCHARD.

Plowing,	$11 55
Harrowing,	3 11
Staking out,	80
Furrowing for trees,	1 78
650 trees at 7c.,	45 50
55 trees at 6c.,	3 30
Freight on trees,	8 64
Fertilizers,	27 95
Freight, mixing and applying,	6 75
Carting trees and fertilizer,	2 22
Pruning trees, dipping and heeling-in,	4 82
Lime sulfur,	75
Setting trees,	6 14
Leveling orchard after setting,	3 38
	$126 69
Credit by 20 trees sold,	1 40
	$125 29

COST OF CULTIVATION AND CROPPING THE FIRST SEASON.

Harrowing,	$2 44
Furrowing out for crops,	1 78
Dropping corn and snap beans,	3 50
Covering corn and snap beans,	1 12
Seed, including express,	5 80
Lima beans for planting,	3 30
Planting same,	1 33
Lima beans for replanting,	1 70
Replanting,	1 00
Labor, cultivating,	8 55
Labor, hoeing,	21 18
Picking snap beans,	1 33
Picking corn,	7 50
Cutting corn for fodder,	2 00
Picking lima beans,	3 00
Putting in cover crop, including cost of seed,	9 23
Time of foreman making notes of labor @ 25c. per hour,	2 50
	$77 26

Credits.

Snap beans,	$5 75
Sweet corn,	47 70
Fodder,	5 49
Lima beans,	34 75
Total,	$93 69
Labor, etc.,	77 26
Balance over cost of cultivation,	$16 43

Expense of putting out orchard,	$125 29
General management first year,	77 26
Total,	$202 55
Credits,	93 69
Balance,	$108 86

The value of the crops grown in the orchard during the summer exceeded the cost of cultivation by $16.43. This amount would have been much larger if the soil had been well fertilized and cultivated a few years before being set to peaches. This should be done in every case to give the young peach trees a vigorous start.

The backward season prevented the carrying out of the season's work as it was planned. Plot 13, which was planted to snap beans, would have been made to produce a second crop in a normal season. It was the intention to get the sweet corn out of the orchard in time to start various cover crops in certain plots, but this could not be done as early as desired so crimson clover was sown in the corn at the last cultivation and among the beans also to make the treatment the same over the whole.

The Training School purchased the various crops as they matured, and the price settled upon in each case was considered to be a fair average for the season after considering prevailing prices and conditions. Snap beans were charged at 50c. per basket, sweet corn at 75c. per 100, and lima beans at 50c. per basket. The sweet corn was early and good and at the time of the first pickings corn was bringing good prices in Philadelphia and New York. At the first, lima beans were also commanding good prices but fell off rapidly toward the end. The lima beans, however, gave the largest net profit per acre, while the snap beans fell slightly below. The object of the experiment is not to determine which is the most profitable crop to grow in the young peach orchard for that obviously varies with the location and with reference to market and to the season. In order to properly carry out the cover-crop experiments that are planned, it is necessary to get the vegetable crop out of the way by midsummer. Such a crop as melons could not be grown, as these need to be manured in the hill for the best results, and that

would interfere with the fertilizer experiments. The bush limas are to be grown upon the same plot each year, the object being to determine whether they will produce sufficient organic matter so that it will not be necessary to use a cover-crop.

The cost of putting out a peach orchard should not vary to a great extent where soil conditions, etc., are quite similar. But location with reference to market, the kind of market, whether wholesale or retail, the season, and most important of all, the kind of a man who is managing the business, all influence to a great extent the credit side of the ledger. If the location is at all favorable for peach and vegetable growing, one should be able without much difficulty to crop his orchard the first year, and receive enough for the produce to more than pay the cost of cultivation after the orchard is set. In the peach experiments at Vineland and High Bridge, the fertilizer was applied as soon as the trees were set and harrowed in, and no additional fertilizer was added when the crops were planted.

The statement has been made many times that corn should not be grown in a young peach orchard upon sandy soils as it checks the growth of the trees. The fault probably lies with the system of management. Some growers set their trees in early spring and apply no fertilizer until the corn is planted, and then it is placed directly in the drill with the corn. It is very evident that the corn gets all the benefit and the trees starve for food that was never given them. Of course corn might be planted so close to trees that it would injure them, but it is very likely that the trouble has been the system of fertilization. The trees should be considered first and the crop second if you are to have a profitable peach orchard in the end. It is true that on soils of only medium fertility the grower is not likely to get a very large net profit from his crop in the young orchard if he makes a charge for all his labor, and this may seem discouraging to some who are really in need of every dollar they can produce in the growing season, but the ultimate result should be kept in view. Very few growers keep an account of labor expended upon their various crops; if they did some of the net profits would not be as large as imagined, while others would prove to be larger.

Fig. 5. Illustration of the cultivation of the peach trees with a "riding cultivator" the first of the season.

The time of the Horticulturist spent in dipping trees in lime sulfur, pruning, setting, mixing and applying fertilizers and other general work is charged in the account against the orchard. Time spent in occasional visits to the orchard with perhaps a few moments spent in work at such times is not figured with the expense. All fruit growers who are in the least interested in their work go into their orchards at various times to see the development of trees and fruit and often do a little pruning, or some other little piece of work while going about the orchard.

The number of trees set was 675. A few in excess of the number to be used were ordered so as to be able to discard any weak or injured trees. It does not pay to cultivate a weak or poor tree any more than it does to keep a poor cow. A few extra trees were also desired for setting in a row near the orchard where any of them could be transferred to the plots in case some trees failed to grow.

The cost of preparing the land was $4.58 an acre, while the cost of the trees pruned, dipped in lime sulfur, and set, including leveling of the orchard, amounts to $19.34 per acre. Where trees are set 20 ft. apart each way this last item would not exceed $17.00 an acre. The net cost of each tree at the end of the first year in the experiment at Vineland was 16 cents.

Experiment with Different Grades of Peach Trees.

In making comparisons between plots having different fertilizer treatment, and between individual trees in various tests at Vineland and High Bridge, it is very desirable to know definitely what variation in growth may be expected from trees of different grades. It is also the object of the experiment to determine what differences are likely to be lasting under the same fertilizer treatment, and whether extra weight and vigor at one year old may ever be an indication of individual worth and economic value if properly handled. It is very evident that even extra good trees if improperly handled by either the nurseryman or the fruit grower will make a very unsatisfactory growth.

Some growers prefer small trees that will caliper about ½-inch, while others prefer large trees that exceed the ¾-inch grade. The objection to the large trees claimed by many growers

is that they fail to start well at the top if cut back to 18 inches or 2 feet. This is likely to be the case with the usual type of the larger grades of peach trees, as any tree which makes a rapid growth does not mature vigorous buds at the base. We have, however, two types of trees among the heavier grades; trees that have grown to a height of from 5–7 feet in the nursery and have made only slender, willowy side branches; and trees that have grown to a height of from 5–7 feet and made vigorous side branches. The buds upon the side branches of the last type mentioned are well developed and sure to grow; but those upon the slender, willowy branches of the first type mentioned often fail to start into growth, especially if the tops of the trees have become rather dry. It is often recommended to cut the top of a peach tree back to stubs when it is planted. This should be done with trees that have strong side branches, but those with slender branches even of the larger grades may as well be pruned to whips.

It has been observed that the large, vigorously branched trees if properly handled and set, generally make a stronger growth the first year than any of the smaller grades. Whether this advantage is retained in succeeding years, and is of practical importance, it is planned to determine by this experiment.

Six trees of four grades were secured for this test from a near-by nursery. The trees of the grade called No. 1 were large, strongly branched trees, and were pruned to stubs before planting. Those of grade No. 2 were large trees, and would be classed with No. 1 by the nurseryman. They were generally taller than the trees called No. 1, but the side branches were slender and willowy. Grade No. 3 was lighter in every way than grade No. 2. Grade No. 4 was very nearly the same as grade No. 3, but a difference could be distinguished by the eye. It is likely that these last two grades will make about the same amount of growth.

All of the trees were of the Elberta variety except No. 6 of grade No. 1, which is Carmen, and were nice trees and free from injuries of any sort.

The caliper, height, total growth, and weight of each tree, pruned ready to set, are given in the following table.

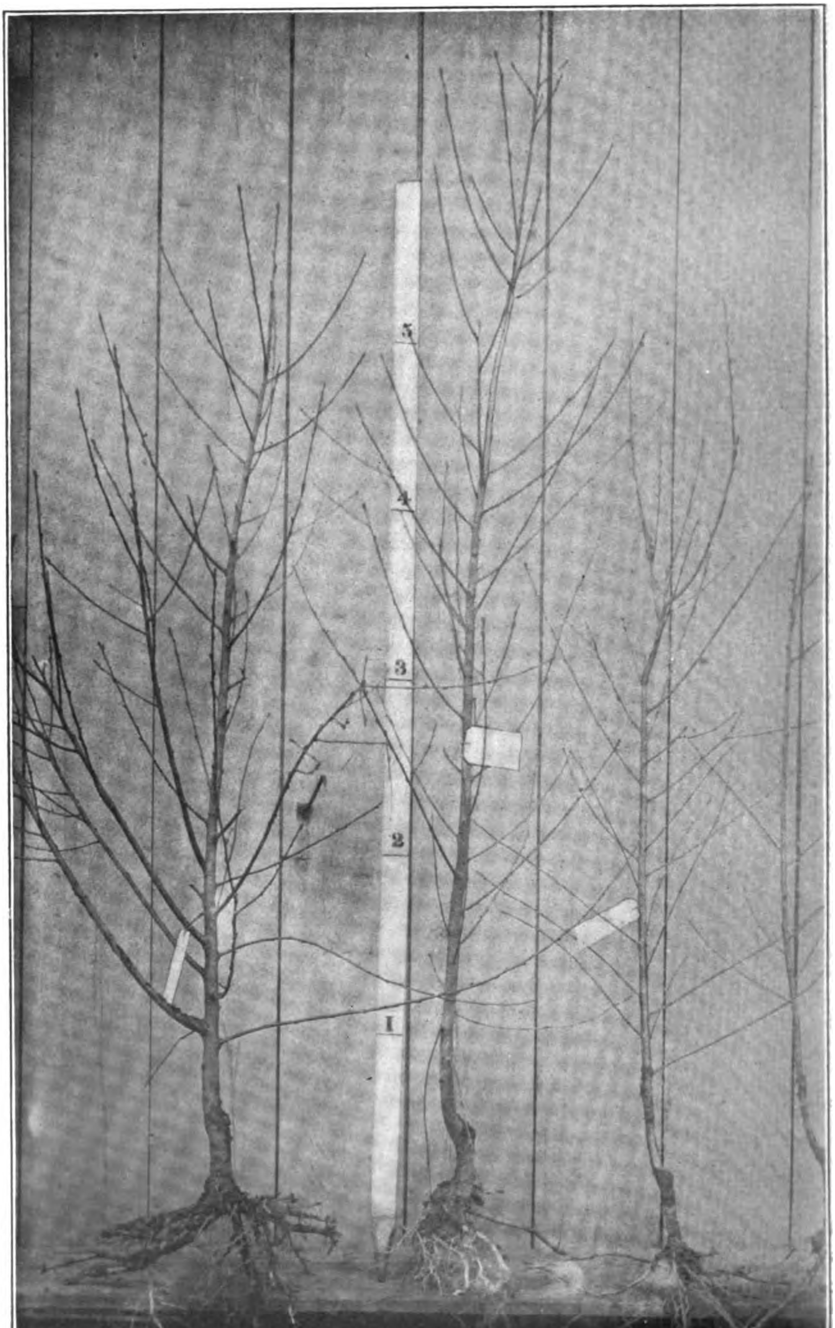


Fig. 6. **Illustration of the different grades of peach trees used in experiment.**

Grade.	Number.	Caliper.	Height.	Total growth.	Total weight.	Pruned to set.	Notes.
		Inches.	Inches.	Inches.	Ounces.	Ounces.	
I.	1	1	60.0	1023.0	45.5	28.5	Nurserymen would grade these trees as "First Class, 5-6 feet."
	2	7/8	63.0	796.0	31.0	21.0	
	3	1	68.0	916.0	43.0	28.0	
	4	7/8	62.0	759.0	32.0	22.0	
	5	7/8	65.0	567.0	27.0	19.0	
	6	1	65.0	1116.0	44.0	27.0	
II.	1	3/4	79.0	572.0	31.0	19.0	These would also be graded as "First Class, 5-6 feet;" but it will be noticed that they are really much lighter in weight, though of greater height in some cases.
	2	3/4	72.0	489.0	20.5	12.5	
	3	1	65.0	567.0	28.5	18.0	
	4	3/4	68.0	456.0	22.0	14.0	
	5	13/16	73.0	569.0	23.5	13.0	
	6	3/4	71.0	422.0	21.5	14.5	
III.	1	5/8	60.0	422.0	14.5	9.0	These would be classed as "First Class, Medium, 4-5 feet."
	2	4/8	58.5	179.5	9.5	6.5	
	3	4/8	56.0	163.0	8.0	5.5	
	4	9/16	56.0	161.0	8.0	6.0	
	5	4/8	54.0	227.0	9.0	6.0	
	6	9/16	53.0	182.5	8.5	6.0	
IV.	1	5/8	51.0	123.0	7.0	5.0	These will also grade as "First Class, Medium, 4-5 feet." Tree No. 3, though shorter than the others, is heavier and better branched.
	2	7/16	49.0	105.0	7.0	5.0	
	3	4/8	43.0	149.0	7.5	5.5	
	4	7/16	55.0	123.5	7.0	5.0	
	5	7/16	52.0	131.5	7.0	5.0	
	6	7/16	47.0	109.5	6.0	4.5	

The difference in price of the various grades is about $1.00 per hundred when obtained at large nurseries. When purchased in dozen lots the difference is about $0.25.

This plot is fertilized at the following rate per acre:

Nitrate of soda,	100 lbs.
Sulfate of potash,	150 "
Ground bone,	100 "
Acid phosphate,	200 "

The trees were kept cultivated throughout the summer, and market garden crops were grown between the rows.

All the trees of grade I started and grew well. Three trees of grade II did not start at the top and one of grade III. Tree No. 6 of grade III was hit by the cultivator and is a striking example of the influence of such injuries upon the growth of a young tree. All of the trees of grade IV started at the top.

July 1 a little summer pruning was done wherever needed to make the trees form better heads.

A cover-crop of crimson clover was sown soon after mid-summer. November 11 the annual growth made by the trees was measured. The six trees of grade I made a total growth of 4513 inches; those of grade II, 1845 inches; grade III, 1414 inches; and grade IV, 2101 inches. Two trees of grade II started at the base and were pruned to one shoot about mid-summer; this lowers somewhat the amount of total growth for this grade. Trees No. 5 and No. 6 of grade III were injured in cultivation, which also lowers the total for this grade. At first the injury to the trees appeared to be very slight, but it soon began to show in the small amount of growth being made. The injury done in careless cultivation is far greater than is generally estimated.

The smallest amount of annual growth made by any tree of grade I was 427 inches. This is larger than the smallest amount made by any tree of any of the other grades. The largest amount of growth, 1300 inches, was made by tree No. 3 of grade I. This tree pruned, ready to set, was heavier than any other with one exception. The trees of grade IV made a fine growth but did not overtake those of grade I; this they may do in another year or two, however. Trees that start from the base and not from the top when set, generally do not make as good a growth as those of the same grade that start directly from near the top. Strongly branched trees of good size, pruned to stubs, and properly set, make a good growth under most conditions, but if trimmed up by the nurseryman previous to shipment so that it is necessary to cut them to whips, they do not start as well and do not make any better growth than some of the smaller grades, which are cheaper.

Brown Rot of Peaches.

This disease has caused so much injury in the southern half of the state the past season, and is so little understood by many of the fruit growers, that it seems important to give it some attention in this report.

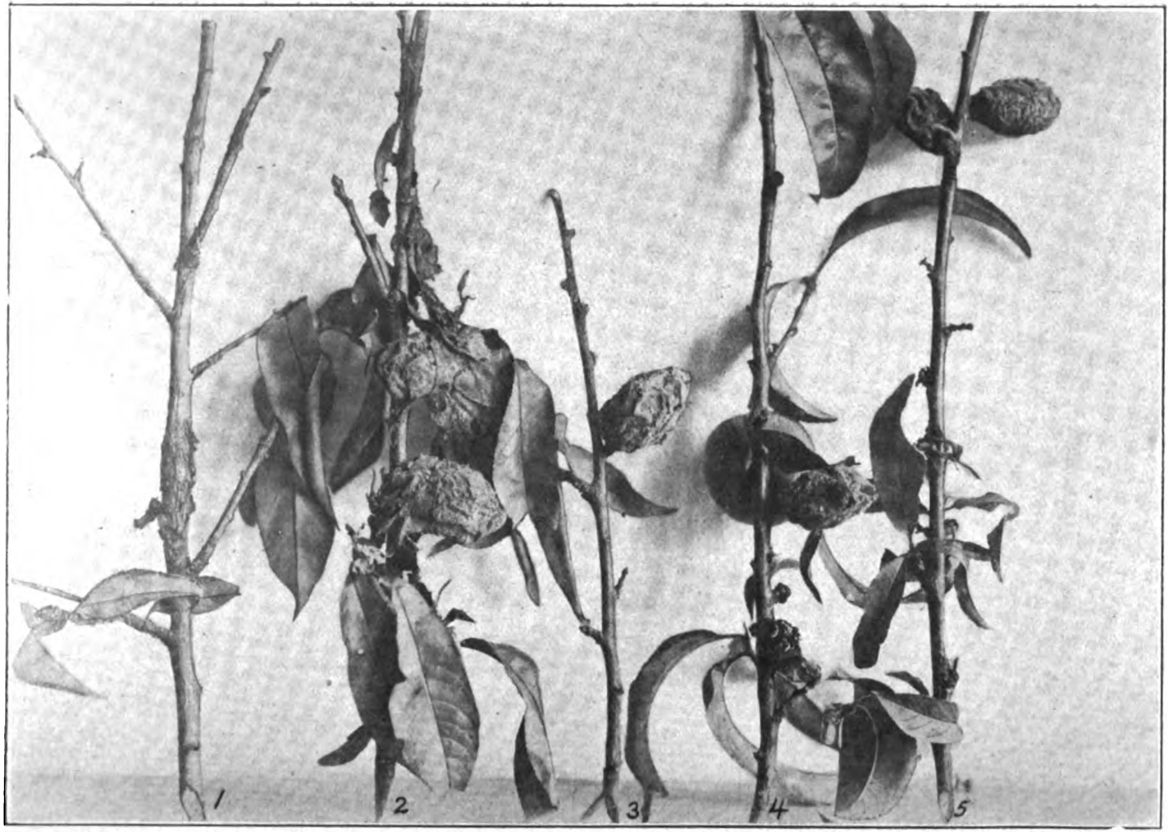


Fig. 7. Peach twigs and fruit affected with brown rot. Twig No. 1 is dead above the affected part.

There was a good crop of peaches in the state last year, and ideal conditions for the rapid development of brown rot prevailed at picking time. Immense numbers of spores were produced and scattered through the orchards, and this accounts for the unusually severe outbreak of this disease, at the present time. Orchards which produced fruit the past season plainly showed a thorough infestation, while those that did not produce fruit showed the presence of the rot, but it was not so apparent to the casual observer.

The brown rot has been a source of trouble to fruit growers for years, but the extent of injury has varied greatly. Weather conditions and other factors play a very important part in the development and spread of this disease. Sheltered and moist locations, too thick planting, the variety of fruit set, and warm, moist weather conditions just before, and at ripening time favor its development.

The rot attacks other fruits, such as plums and cherries, besides the peach. Only one stage of the disease is generally understood by the peach grower, and that is the rotting of the fruit upon the trees. Many of the decayed fruits dry up and often cling to the branches throughout the winter. It may be noticed at the time the fruit is decaying that some of the small branches in the center of the tree are dying, especially if the top of the tree is thick and not properly pruned. This may be due to the brown rot. The mummied fruits are covered with brown spores, and they may also be found upon the dead branches and in the crevices of the rough bark. From such sources immense numbers of spores develop and spread the following spring. If the weather conditions are favorable the rot often destroys many of the blooms before the fruit sets. As high as 75% of the bloom may be injured at this stage. The writer saw considerable injury of this kind in orchards about Vineland the past spring. The cold, unseasonable weather was accused of the poor set of fruit, when the brown rot should have been blamed for a share of the damage in many cases. This injury to the blooms by the rot may be readily distinguished from frost or cold injuries because the affected blossoms cling to the twigs for a time after being killed and there is often an exudation of gum, and a close

examination of the blooms will show the brownish growth of fungus. Short twigs and spurs are often killed at this time by the disease in working downward from the dead blossoms. The exudation of gum may also be noticed where a decayed peach has come in contact with a twig or branch. Small twigs thus affected often die in a short time. The larger branches may continue to grow and set fruit, but the diseased parts are likely to prevent the proper circulation of the sap and cause a tendency toward premature ripening, even if the fruit upon the branch escapes infestation from the affected part.

The killing of the twigs sometimes develops to such an extent that all are killed in the center of a tree. This is very apt to happen with such varieties as Triumph, which often rots before it ripens.

Professor Norton of Maryland found that the spores upon mummied fruits, which fall to the ground and are covered with soil, may remain dormant until the second year, and these being brought to the surface by cultivation, develop, and are again a source of infestation.

SUGGESTIONS FOR CONTROL.

In selecting a site for a peach orchard keep in mind the importance of good air drainage.

Do not set varieties like Triumph.

Prune your trees so that they will form open heads.

If old trees are headed back they will need thinning after one season's growth.

Gather all mummied fruits and infested twigs and burn them.

Spray with copper sulfate at the rate of two pounds to 50 gallons of water before the buds start in the spring, or spray with Bordeaux just before the buds burst into bloom.

Spray several times during the summer with copper carbonate.

Don't spray with Bordeaux after the leaves expand. The peach foliage is sensitive and liable to spray injury.

Don't be sure your trees are free from the brown rot if it fails to develop in any one season; weather conditions may have checked it. Keep the orchard clear of infested fruit and twigs.

Experiments are being planned with reference to determining the most economical methods of keeping this disease under control in the peach orchards. It is expected that these will be undertaken next spring in some of the badly infested orchards in the southern portion of the state.

Sand Cherry and Americana Plum as Peach Stocks to Control the Peach Borer.

Having seen the peach successfully propagated and grown upon sand cherry and Americana plum by Professor Waugh, and noting the great injury done to peach trees in this State by the peach borer, it occurred to me that this insect would not be likely to work in sand cherry. The evidence in regard to the plum is somewhat conflicting. Some growers claim that the peach borer will work in the plum as well as in the peach stock. This does not seem to be the case at this station, however, and plum trees that are upon peach roots show no attack where the union is well below the surface of the soil.

A few Elberta peach upon sand cherry and Americana plum stock were secured from the Massachusetts Agricultural College last spring and set upon a plot where badly infested seedling peach trees had just been taken out.

The trees obtained had been budded low like all nursery trees, and in one upon sand cherry, where the soil had entirely covered up the union during cultivation, I found a small peach borer, but it had done all of its feeding in the peach wood. It was evident that the sand cherry stock should come above the surface of the ground to get the best results.

The sand cherry and Americana plum as stock for the peach tend to dwarf it somewhat and bring it into bearing earlier. The fruit is just as large as upon standard trees; but the peach cannot be propagated upon either the sand cherry or the Americana plum as cheaply as it can upon peach roots and the trees are inclined to overgrow the stock.

No borers have appeared in any of the trees propagated upon sand cherry set this last spring, though they are present in young trees propagated upon peach roots nearby.

It is not yet certain whether peach upon sand cherry or Americana plum will prove to be of value to the commercial peach grower, but they may be adapted to the fruit garden; the digging out of borers is often neglected by people having only a few trees. The dwarf habit and early bearing tendency would also be advantageous.

The real question seems to be that of growing the trees so that they will not outgrow the stock at the union and make them liable to breakage. This point is now being studied. Records of the yields of trees upon sand cherry and Americana plum stock will also be kept.

Preservation of Greenhouse Benches.

This experiment was begun in 1905, and a report of the details of the work and the results may be found in the annual report for 1906.

Another year has served to point out, more prominently the value of the various materials as preservatives, and which are the more lasting in their effects.

Three applications of thin whitewash preserved the wood to some extent, but the effect was not lasting as considerable decay occurred this last season.

The benches receiving cement alone are in nearly the same condition as those receiving whitewash.

Spraying the boards with three applications of copper sulfate is much more effective than either the whitewash or cement but does not prevent some decay.

Creosote does not appear to be any better than cement or whitewash.

The bench treated with S. P. F. Carbolineum is now showing some decay, which indicates that it is not very lasting in its effects, though it did very well at first.

An application of copper sulfate, followed by an application of cement, gave somewhat better results than the application of copper sulfate alone.

Coal tar preserves the wood to about the same degree as the copper sulfate followed by an application of cement.

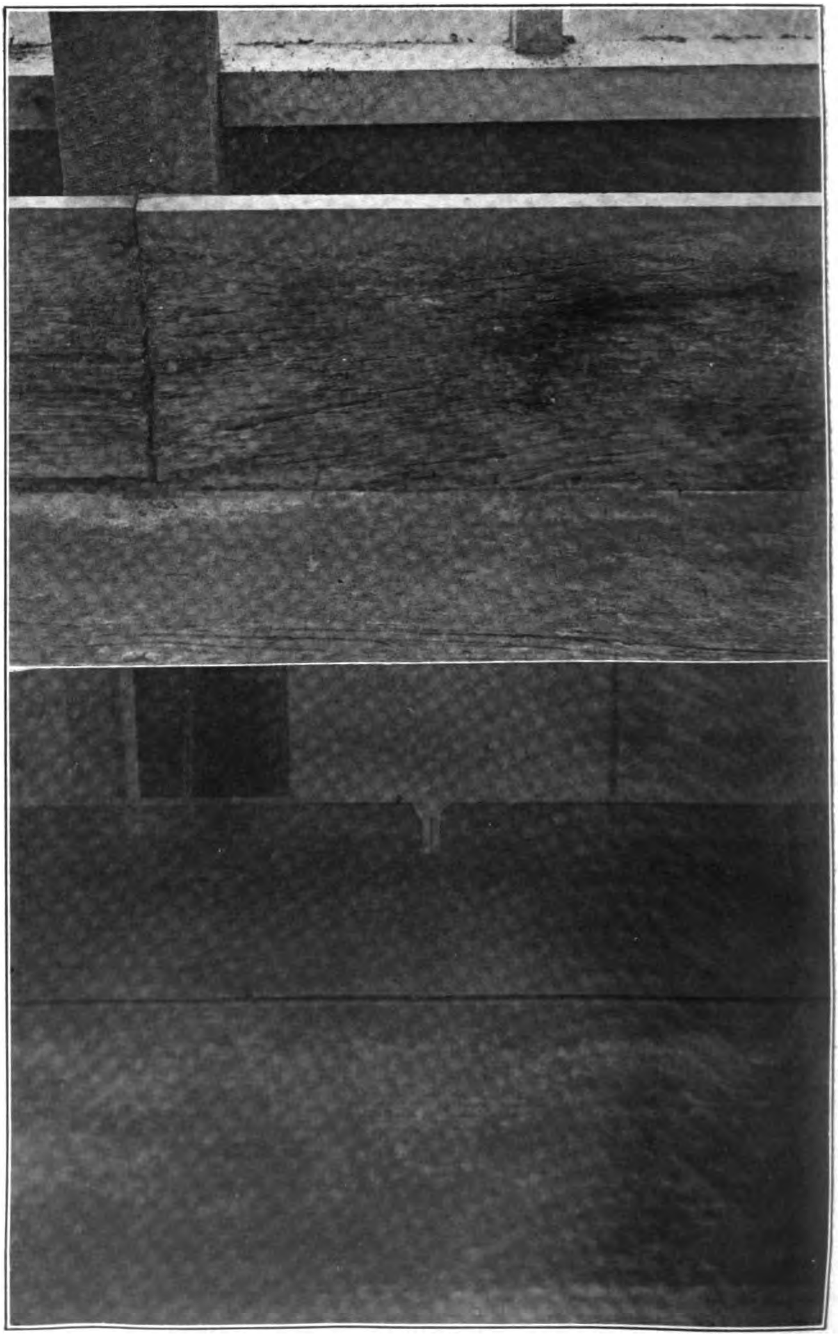


Fig. 8. The upper half of the figure illustrates a portion of a bench not treated to preserve the wood. The lower half of the figure illustrates a portion of the bench treated with applications of a solution of copper sulfate and then with an application of whitewash.

The best preserved benches of all are those that were treated with a solution of copper sulfate followed by whitewash; and the bench which received one spraying of copper sulfate and three of thin whitewash, appears to be as well preserved as those having two sprayings of copper sulfate and three of whitewash. There is practically no decay shown by the boards thus treated with the exception of one small spot upon one board. This may not have received an even application of the materials, or might have been exposed to an extra amount of drip from the glass at sometime.

The application of a solution of copper sulfate followed by whitewash appears to be considerably the best preservative of those tested for greenhouse benches. The suggestion in the last report appears to be correct, that the more insoluble compounds of copper hydrate and calcium sulfate are formed in the wood. Further experiments to determine this are being carried out.

The copper sulfate-whitewash combination is not only effective, but inexpensive and easy to apply. One pound of copper sulfate costs about 8 cents and is sufficient for 40 feet of board surface.

This is worthy the attention of all greenhouse men who are using wooden benches.

Strawberry Tests.

Strawberries are one of the important crops of the State, and a number of varieties have been set at the College farm as a variety test and as a beginning toward further investigations with this fruit. Some of the standard varieties have been included in the list to make more accurate comparisons of the newer varieties.

The following varieties were set last spring:

Amanda,	Golden Gate,	New York,
Bradley,	Jessie,	Pan-American,
Cameron,	Johnson's Early,	Parson's Beauty,
Climax,	Latest,	Sample,
Clyde III.,	Mead,	Senator Dunlap,
Commonwealth,	Michael's Early,	Texas,
Early Hathaway,	Mrs. Miller,	Steven's Late Champion,
Gandy,	Nettie,	Warfield,
Glen Mary,	New Home,	3 W.

In the variety test these are all grown in the single hedgerow system. Some of them are also being grown in the double hedgerow and matted-row systems.

MURIATE AND SULFATE AS SOURCES OF POTASH FOR STRAWBERRIES.

The influence of these two different sources of potash upon the color and firmness of the fruit is often questioned. The object of this test is to determine what effects and differences these two forms of potash are likely to produce. The two plots in the experiment are of equal size and contain the following varieties grown in the double hedgerow system:

Gandy,	Sample,
Clyde III. (two rows),	Parsons,
Senator Dunlap.	

Further Experiments with Apples.

Another experiment with apples was planned and started last spring. The principal features of this experiment are a comparison of high grade sulfate and muriate as sources of potash for apples; the determination of the economic value of a leguminous cover-crop such as cowpeas as compared with nitrogen in the form of nitrate of soda; and a test of a leguminous cover-crop with a non-leguminous cover crop to determine their difference in economic value in orchard management. Dwarf apples were used instead of standards to obtain more immediate results. This will also permit of a study of the dwarf apple, which should throw light upon many points which are under discussion in regard to its cultivation and value.

The orchard is divided into six plots, the fertilizer treatment per acre of which is as follows:

Plot 1.	Nitrate of soda,	100 lbs.
	Muriate of potash,	100 "
	Ground bone,	100 "
	Acid phosphate,	150 "

Plot 2.	Nitrate,	100 lbs.
	Sulfate,	100 "
	Bone,	100 "
	Acid phosphate,	150 "
Plot 3.	Cover-crop.	
	Sulfate,	100 lbs.
	Bone,	100 "
	Acid phosphate,	150 "
Plot 4.	Cover-crop (same as Plot 3).	
	Muriate,	100 lbs.
	Bone,	100 "
	Acid phosphate,	150 "
Plot 5.	Legume cover-crop.	
	Sulfate,	100 lbs.
	Bone,	100 "
	Acid phosphate,	150 "
Plot 6.	Cover-crop (non-leguminous).	
	Sulfate,	100 lbs.
	Bone,	100 "
	Acid phosphate,	150 "

Bismarck, Baldwin, Duchess, Gravenstein and Jonathan are the varieties used in this experiment and these were all propagated upon Doucin apple stock.

The trees were set 10x8 feet apart on April 24, and a crop of sweet corn was grown between the trees during the summer.

August 7 a cover-crop of cowpeas was sown upon Plots 3 and 4; hairy vetch upon Plot 5 and rye upon Plot 6.

Experiments with Sterilized Manure to Control the Mushroom Maggot.

The chief obstacle to the growing of mushrooms during the summer months is the mushroom maggot. Temperature is an important factor and it is necessary to have a favorable place in which to grow the crop, but many growers who have suitable places have given up trying to produce mushrooms during the summer months because of the damage caused by the maggot.

The mature insect is a very small fly which will find its way into the darkest of cellars. Sometimes crops in caves are not

attacked, and this is occasionally the case with crops grown in cellars and other places, but these are generally the exceptions.

The plan of the experiment was to sterilize the manure with steam just before it was ready to be placed in the bed and thus destroy all eggs of the mushroom fly which it might contain; then to make up the bed in a cellar which had been made tight and screened to prevent any of the flies from entering and depositing eggs.

A small, moist cellar, the temperature of which was about 60°–65° during the summer months, was selected as a place to carry out this experiment. It was divided into two parts by erecting a board partition and this was covered with building paper to make it absolutely tight. There was an air shaft in each half of the cellar for ventilation and these were covered with very fine wire.

The object of dividing the cellar into two parts was to secure the same conditions of temperature and moisture for the bed made up of the sterilized manure, and the check bed made with unsterilized manure, and yet prevent the flies from getting to the sterilized bed. At the suggestion of Dr. Smith a vestibule was made between the two parts of the cellar; one door was made of boards covered with building paper, and the other was covered with wire of a very fine mesh.

The manure was prepared in the usual manner in the cellar of the stable which is a short distance from the mushroom cellar. When the manure was ready for placing in the beds it was divided into two parts, and one-half was sterilized.

A large, strongly made box was fitted up with a ¾-inch pipe, with ¼-inch holes bored at every six inches, which would permit the steam to enter all parts of the box evenly. The cover of the box was made to fit tightly and was fastened down with thumb screws. Such an apparatus can be fitted up very cheaply.

The box was taken to the rear of a building where steam could be run into it, and after it was filled with the prepared manure it was subjected to steam for an hour. Three to four pounds pressure was used a large part of the time; but the sterilizing could be done with much less pressure though it would require a longer time.

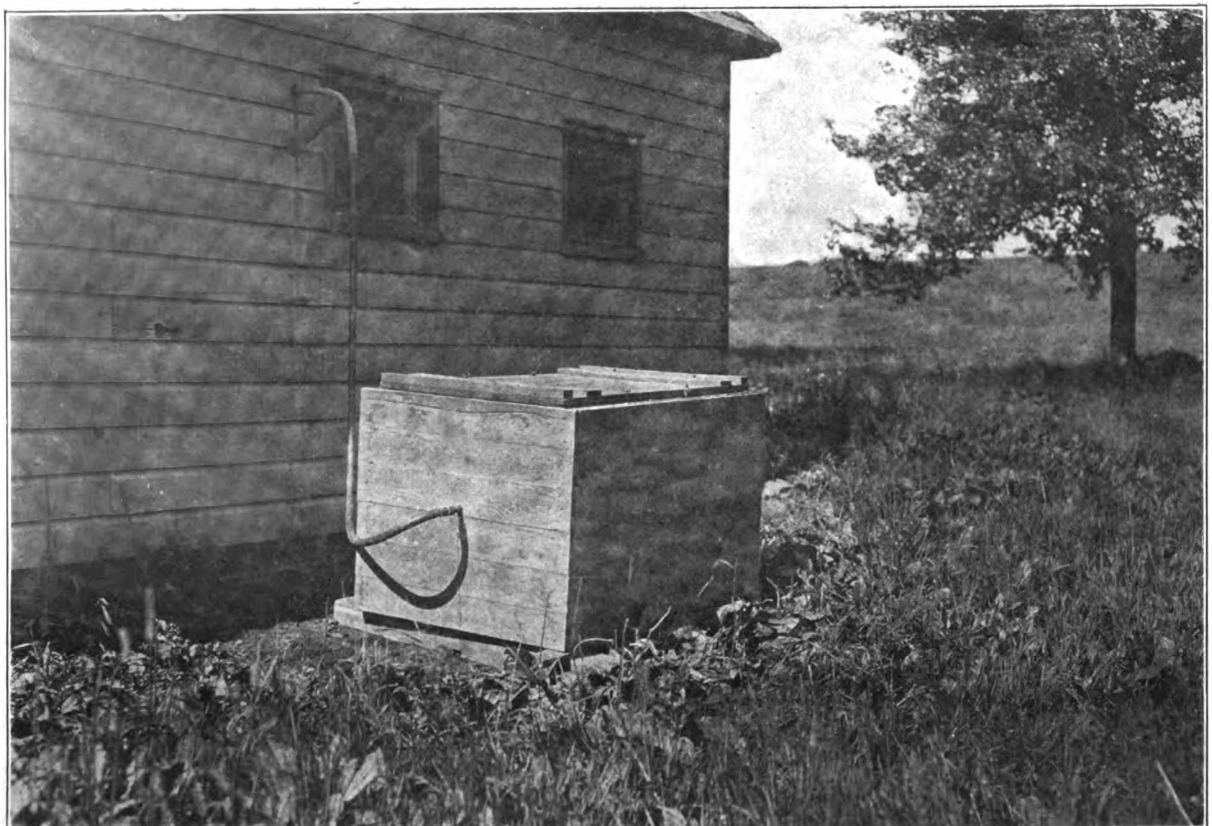


Fig. 9. Illustration of the box used in the sterilization of the manure for the mushroom experiment.

The box containing the sterilized manure was taken to the cellar and the bed was made up shortly after. A small amount of good loam was mixed with the hot manure and the bed prepared in the usual way. This part of the cellar was fumigated a few hours later with potassium cyanide to make sure that no flies had entered.

The unsterilized half of the prepared manure was then brought down to the adjoining half of the cellar, mixed with good loam in the same proportions, and a bed made up in a similar manner.

The unsterilized manure was swarming with small manure flies and they were present in the cellar throughout the experiment.

Both beds were spawned July 22 with Eureka and Almond Cream varieties of the "Pure Culture" spawn, each bed receiving equal amounts, and about 10 days later the beds were cased with good loam.

Several mushrooms began breaking through in the unsterilized bed on September 6, but it was not until September 12 that any appeared in the sterilized bed, then quite a large number at once. This bed appeared to be much more uniform than the check.

The yields of the two beds were as follows:

STERILIZED.			UNSTERILIZED.		
Date.	Number.	Weight. in Oz.	Date.	Number.	Weight. in Oz.
Sept. 18,	2	3½	Sept. 12,	2	6
" 19,	6	5	" 18,	1	4
" 30,	33	17½	" 19,	4	5
Oct. 21,	8	4	" 21,	7	5
" 31,	15	4	Oct. 2,	4	8½
			" 8,	6	10
			" 21,	5	6
			" 31,	1	½
	64	34		30	45

After several quite heavy rains the latter part of October, water worked into the cellar and wet the beds at the bottom, which checked production. Not a single maggot was found in any of the mushrooms from either the sterilized or unsterilized

beds. The effect of the sterilized manure upon the growth of the mushrooms is important, however. The process of sterilization changed the condition of the manure, and the two beds behaved quite differently. The sterilized bed was the more uniform and more moist throughout the test. It produced more than double the number of mushrooms, but they were less than half the weight of those produced by the unsterilized bed. If this decrease is size and weight is due to the destruction by sterilization of certain bacteria in the manure, which act beneficially to the growth of the mushrooms, this system is not practicable in controlling the maggot. It may, however, be due to the condition of the manure with reference to moisture and other factors. This point will be given further study.

Asparagus Breeding.

A few years ago the asparagus rust was causing serious injury to the asparagus industry throughout the state, and an experiment was planned in an effort to obtain a strain of plants that would be resistant to the disease.

Seed was obtained from many different sources including a number of seedsmen, several states, and from France. Seed was also secured from the following asparagus growers who made selections from special plants: C. C. Hulsart, E. T. Ridgeway, J. C. Hendrickson, John G. Whitall, H. W. Ridgeway and Chas. Tindall.

The seed was planted in the spring of 1906. No rust has developed upon any of the plants as yet, but it has been very much less severe in all sections of the state for the last few years.

This selection of seed in an effort to control the rust brings up another important matter, the selection of seed with reference to the size and vigor of plant and crowns. The asparagus grower desires plants that produce large stalks. All plants will not do this even under excessive fertilization. Some have an inbred tendency to produce a large number of small crowns which send up small stalks for cutting. Seed should be selected from ideal plants that have received pollen only from desirable plants and

then only the heaviest and best seed from these plants should be used, and also any weak or poor plants which may result from these should be thrown out. The differences in vigor of the plants obtained from the seed secured for the asparagus breeding experiment were very great.

The list of sources from which seed was obtained follows:

Number.	Variety.	Quality of Plants.	Source of Seed.
1.	Palmetto,	Good,	James Vick's Sons.
2.	"		Thorburn: Grown in South Carolina.
3.	"		Burpee: Said to be grown in North Carolina from rust-resisting plants.
4.	"	Small,	Elbert: Seed grown at San José, Cal.
5.	Bonvallet's Giant,	Medium,	Vaughn: Illinois-grown seed. Really an improved Palmetto. In demand in Chicago market. Said to be very large, early and resistant to rust.
6.	Similar to Conover's Colossal,	Small,	Johnson & Musser: Said to be almost immune from rust. Seed grown in the west.
7.	Palmetto,	Good,	Chas. Tindall, New Monmouth.
8.	Palmetto,	Good,	C. C. Hulsart, Matawan.
9.	"	Good,	E. T. Ridgeway, Mullica Hill. Seed selected from rust-resisting plants.
10.	"	Medium,	College Farm. Seed selected from best plant in experiment plots.
11.	"	Small,	College Farm. Seed selected from rusted plant.
12.	"	Good,	Jas. C. Hendrickson, Middletown. Seed selected from rusty plant growing near good plants.
13.	"	Small,	Jas. C. Hendrickson: Seed from good plants grown near No. 12.
14.	"	Good,	John Whitall, Woodbury. Seed selected from plants affected by rust.
15.	"	Fair,	John Whitall: Seed from plants free from rust.
16.	Argenteuil,	Good,	Vilmorin Andrieux & Co., Paris. Imported.
17	"		" " " " " Different sample of seed.
18.	"	Good,	Dreer. Seed imported from France.
19.	Early French Giant,		Johnson & Stokes: Seed grown in South Carolina. An improved Palmetto and said to be earlier and larger.

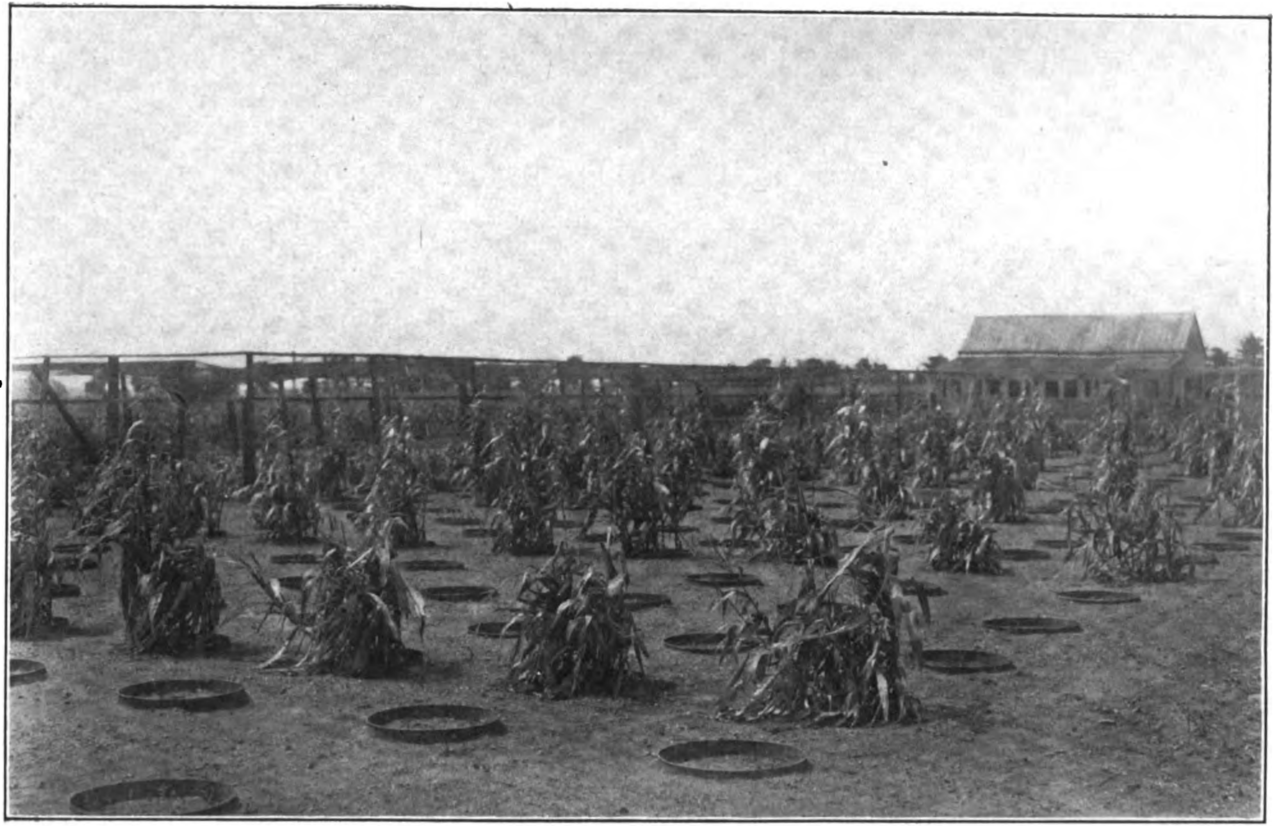
Number.	Variety.	Quality of Plants.	Source of Seed.
20.	Argenteuil,	Good,	College Farm: From poorest, rusted plant.
21.		Good,	John Whitall: From field that rusts badly.
22.		Small,	John Whitall: Seed selected from plant almost free from rust, but surrounded by rusted plants. Stalks of plants small.
23.		Small,	H. W. Ridgeway: Seed selected from good plant.
24.		Good,	J. C. Hendrickson: Seed selected from best plants in field.
25.	Palmetto.		Vaughn: Seed grown in New Jersey.
26–27	"		Same as No. 1.
28–29	Argenteuil,		Same as No. 16.

The quality of the plants noted in this table is the size of the plants when ready to set one year after the planting of the seed. Some good plants resulted from seed selected from rusted plants. Seed from good plants surrounded by rusted plants, however, generally produced small plants. Good plants in all cases were obtained from the imported seed.

Fifty plants from each of the different lots were set in a permanent bed last spring to enable them to develop and permit of further study.

Row 26 was set with 50 plants of No. 1. These were selected plants having large and few crowns. Row 27 was also set with 50 plants of No. 1, but the plants were smaller with many crowns. Rows 28 and 29 were set with 50 plants of No. 16. Row 29 is to receive no fertilizer and the effect of this is to be noted with reference to the formation of new crowns and their resistance to rust. Rows 26 and 27 are also to be compared with reference to their formation of large and small crowns.

REPORT OF THE SOIL CHEMIST AND BACTERIOLOGIST.



Cylinder Experiments.

Report of the Soil Chemist and Bacteriologist.

JACOB G. LIPMAN.

PERCY E. BROWN, ASSISTANT CHEMIST.

Inoculation Experiments with Azotobacter.

Agriculture can boast of many valuable empirical discoveries made long before the dawn of scientific investigation. These discoveries were frequently chanced upon by accident, and at times were the result of more or less careful observation. But however made, they were not regarded in their general relation to any group of allied phenomena. They remained isolated, and often failed, for this very reason, to yield their full service.

The peculiar quality of leguminous crops as soil enrichers and soil renovators was known to the peasants of the Roman Campagna before the beginning of the present era. It is not probable that this knowledge was acquired suddenly. The observations of individuals included the same fact again and again until it impressed itself on the popular conscience and was finally transmitted as a valued possession to succeeding generations. It was thus that the lupine and the vetch came to be esteemed as green manures by the Italian peasantry, an esteem that was not entirely lost even in the gloom of the succeeding centuries. Lucerne, the *herba medica* of the ancient Romans, sanfoin, and the clovers were later credited with the similar power of restoring wornout lands. The discovery being an empirical one its full effect was not felt until modern research made it the subject of systematic study.

When it was finally revealed to us by such systematic study that the legumes owe their soil-enriching quality to their ability

to assimilate atmospheric nitrogen, and when it was further shown that this ability is acquired only in the presence of certain bacteria, the foundation was laid for a more thorough and more successful application of the empirical discovery. It was self-evident that in the absence of the bacteria the legumes must, of necessity, be devoid of their nitrogen-gathering power, and the thought was near that the well-known failure of clovers and other legumes to grow on certain soils might be due to the absence of the proper bacteria. We come thus to soil inoculation; that is, attempts to supply the missing organisms. This was already done by Hellriegel in his pot cultures and by Salfeld and others in field experiments. Already in 1887[1] Salfeld employed with success old legume earth for the inoculation of reclaimed moor soils; a method resorted to in the United States for the inoculation of recently established fields of alfalfa or of soy beans. The next step in the history of soil inoculation was the introduction of pure cultures as inoculating material. Nitragin in Europe and nitroculture in North America have had a varied career which it would be out of place to discuss in this paper.[2] It is sufficient to point out here that the utility of inoculation for certain soils and crops is no longer questioned, nor is there any question as to the theoretical advantages of pure cultures for inoculation purposes. The practical application of pure cultures is still a fruitful field for further inquiry.

With the isolation of the nitrogen-fixing Clostridium Pasteurianum by Winogradski, it was definitely shown that nitrogen assimilation may be effected by the organisms independently of the higher plants. Later the group of non-symbiotic nitrogen-fixing bacteria was augmented by Beyerinck's isolation of Azotobacter in 1901; and later still it was demonstrated that a considerable number of other species possess a slight, but none the less appreciable power of fixing atmospheric nitrogen. With the isolation of these organisms the problem of soil inoculation became much broader, for the addition of nitrogen compounds to the soil by bacteria assumed wider possibilities. Accordingly,

[1] Deuts. Landw. Presse 15 (1888), No. 99, p. 630.

[2] See Bull. 194, Office Experiment Stations, U. S. Dept. of Agriculture, Washington, D. C.

we find a record of some attempts at soil inoculation with aerobic, as well as non-aerobic nitrogen-fixing bacteria. These attempts have failed almost uniformly to yield positive results, a circumstance which, perhaps, will be understood more clearly in the light of the following considerations.

Clostridium Pasteurianum and allied species are almost invariably present in arable soils; while Azotobacter is also widely distributed. This being the case, what advantages are to be expected from mere additions of such organisms to the soil? Theoretically the advantages may be two-fold. Even when present in the soil, these organisms may occur there in numbers so few as to preclude rapid and extensive nitrogen fixation, when the conditions are rendered suitable for their development. Again, the organisms though present in the soil in comparatively large numbers may yet be so feeble in their power of nitrogen fixation as to add scarcely any combined nitrogen to the soil. From the standpoint of numbers and from the standpoint of physiological efficiency, therefore, soil inoculation with these organisms has in it a distinct promise of usefulness. But with that much admitted, the fact cannot be too strongly emphasized that the bacteria already present in the soil, or those employed as inoculating material can add nothing to its nitrogen store, unless they be given full opportunity for rapid and vigorous growth. It is for future research to decide whether proper soil treatment may be alone sufficient as a means for establishing the desired bacterial activities, or whether the best results may be secured by combining soil improvement with soil inoculation.

In the inoculation experiments recorded in the following pages full cognizance was taken of the facts just noted. The soils under experiment were subjected to various methods of treatment with or without inoculation and a careful account was kept of the nitrogen present in the soil and in the crops removed. The treatment included additions of lime in varying quantities, additions of Thomas slag, or of manure, and additions of these materials in combination. It was hoped that on account of the important relations of lime, of phosphates, and of organic matter in the development of Azotobacter, the effect of these substances would be apparent in the crop yields on the inoculated soils.

The soils under experiment were placed in cylinders four feet long, open at both ends, and sunk into the ground until the rims were about 1½–2 inches above the level of the surrounding soil. The cylinders were filled with a uniformly mixed subsoil to within 10 inches of the top, and 8 inches of the soil were then added. The soil weighed in each case about 88,000 gms. when in an air-dry state. It was originally made up of equal weights of red shale and of quartz sand, and contained, in each cylinder, abount 90.0 gms. of total nitrogen.[1] During the years 1898–1903 the different systems of manuring in the several series introduced differences in the nitrogen content of the soils. In general all of the soils lost considerable quantities of nitrogen during that time, involving also modifications in their physical properties. In 1902 the average amount of nitrogen in each soil had been reduced to 72.18 gms., and in the spring of 1904 to 71.17 gms. In the spring of 1904 the soils were all removed and placed in one heap, the latter thoroughly mixed, sampled for analysis, and equal amounts placed in each of the 60 cylinders employed in the experiment. It seemed that favorable conditions were offered here for the fixation of atmospheric nitrogen by Azotobacter, since the soil was a sandy loam well aerated yet containing sufficient quantities of fine earth to prevent its too rapid drying out. With the suitable mechanical constitution of the soils in question and the presence of an abundance of the mineral constituents supplied in preceding seasons, there was ground for hope that the fixation of atmospheric nitrogen would actually be encouraged. On May 12th the several cylinder series were treated as follows:

1 A, B, C } Nothing, soil not disturbed.

2 A, B, C } Nothing, soils stirred once in ten days.

3 A, B, C } 28.80 grams $CaCO_3$, equivalent to 1,000 lbs. per acre.

4 A, B, C } 57.60 grams $CaCO_3$, equivalent to 2,000 lbs. per acre.

[1] N. J. Station Report, 1902, p. 170.

5 A, B, C — 14.40 grams Thomas slag, equivalent to 500 lbs. per acre.

6 A, B, C — 28.80 grams Thomas slag, equivalent to 1,000 lbs. per acre.

7 A, B, C — 576.07 grams manure, equivalent to 20,000 lbs. per acre.

8 A, B, C — 864.10 grams manure, equivalent to 30,000 lbs. per acre.

9 A, B, C — 57.60 grams $CaCO_3$+864.10 grams manure.

10 A, B, C — 57.60 grams $CaCO_3$+28.80 slag+864.10 manure.

11 A, B, C — Nothing, soil not disturbed.

12 A, B, C — Nothing, soil stirred once in ten days.

13 A, B, C — 28.80 grams $CaCO_3$.

14 A, B, C — 57.60 grams $CaCO_3$.

15 A, B, C — 14.40 grams Thomas slag.

16 A, B, C — 28.80 grams Thomas slag.

17 A, B, C — 576.07 grams manure.

18 A, B, C — 864.10 grams manure.

19 A, B, C — 57.60 grams $CaCO_3$+864.10 grams manure.

20 A, B, C — 57.60 grams $CaCO_3$+28.80 grams Thomas slag+864.10 grams manure.

All the soils except those in series 1 and 11, were stirred once in about every 10 days. It will be noted that the treatment of the soils 11–20 was parallel to that of 1–10. On May 16th series 11 to 20 were inoculated as follows: Series 11a–20a with

A. Vinelandii; series 11b–20b with A. Vinelandii, and B. 30 var.; series 11c–20c with A. Beyerincki. The soils in series 1–10 remained uninoculated.

During the summer of 1904, the soils were uncropped and kept free of weeds; and, as already noted above, they were stirred once in every ten days. By this means a fair amount of moisture was retained in the soil throughout the summer, sufficient it was thought, to allow the growth of Azotobacter and of other soil organisms.

The soils remained bare until the following April, when they were spaded up and seeded to oats without further applications of manure or fertilizer. One hundred seeds were placed in each soil. The germination was quite satisfactory, and the initial growth fairly vigorous. In a short time, however, the plants began to show by their light color that they were being insufficiently provided with nitrogen food. Growth was best in the cylinders which had received the larger applications of manure alone or of manure in combination with some of the other substances.

On the whole, it was evident that the nitrates formed in the soil in the preceding season had been removed to a great extent by the leaching action of the fall and winter rains, and that a comparatively small proportion was retained for the use of the oats crop. The crops in the inoculated series 11–20, were, to all appearances, no better than the crops on the uninoculated series 1–10. Nor were there any marked differences in the soils of the same series, inoculated with Azotobacter Vinelandii and Azotobacter Beyerincki, respectively. The entire crop was harvested early in July, and determinations made of the dry matter and of the nitrogen in the plants from each soil. The amounts found are recorded in the following table:

THE YIELD AND COMPOSITION OF THE OATS CROP, 1904.

Cyl.	Dry Matter. gms.	Nitrogen. %	Nitrogen. gms.	Cyl.	Dry Matter. gms.	Nitrogen. %	Nitrogen. gms.
1a, ...	72	1.119	0.806	11a, ...	58	1.098	0.637
b, ...	50	1.140	0.570	b, ...	60	1.098	0.659
c, ...	62	1.140	0.707	c, ...	55	1.147	0.631
2a, ...	61	1.104	0.673	12a, ...	72	1.091	0.785
b, ...	51	1.027	0.554	b, ...	65	1.098	0.714
c, ...	54	1.097	0.592	c, ...	66	1.121	0.740
3a, ...	75	1.104	0.828	13a, ...	65	0.993	0.645
b, ...	76	0.979	0.744	b, ...	67	1.067	0.715
c, ...	78	1.059	0.826	c, ...	70	1.159	0.811
4a, ...	83	1.016	0.843	14a, ...	72	1.053	0.758
b, ...	67	1.041	0.697	b, ...	62	1.046	0.648
c, ...	69	1.256	0.867	c, ...	59	1.081	0.638
5a, ...	73	1.027	0.750	15a, ...	66	1.144	0.755
b, ...	72	1.120	0.806	b, ...	70	1.060	0.742
c, ...	58	1.103	0.640	c, ...	63	1.071	0.675
6a, ...	72	0.993	0.715	16a, ...	70	1.074	0.752
b, ...	79	1.046	0.826	b, ...	63	1.062	0.669
c, ...	69	1.099	0.758	c, ...	62	1.080	0.670
7a, ...	61	1.053	0.642	17a, ...	64	1.041	0.666
b, ...	68	1.018	0.692	b, ...	71	1.034	0.734
c, ...	67	1.089	0.731	c, ...	63	1.168	0.736
8a, ...	62	1.053	0.653	18a, ...	68	1.066	0.725
b, ...	60	1.032	0.619	b, ...	62	1.107	0.686
c, ...	71	1.085	0.770	c, ...	64	1.130	0.723
9a, ...	71	1.013	0.719	19a, ...	58	1.128	0.654
b, ...	79	1.030	0.814	b, ...	54	1.075	0.580
c, ...	80	1.157	0.926	c, ...	64	1.054	0.674
10a, ...	68	0.999	0.679	20a, ...	55	1.026	0.564
b, ...	71	1.083	0.769	b, ...	72	1.274	0.917
c, ...	85	1.066	0.906	c, ...	66	1.130	0.746

The yields of dry matter and of nitrogen in the oats crops were not large. The largest yield of dry matter for the inoculated soils was 85 gms. in 10c, and for the inoculated 72 gms. in 12a, 14a and 20b, respectively. Similarly, the largest yield of nitrogen for the uninoculated soils was 0.926 gms. in 9c, and for the inoculated 0.917 gms. in 20b. Hence the maximum yields of dry matter and of nitrogen were smaller in the inoculated series than they were in the uninoculated series. Moreover, in the inoculated soils no consistent differences appear between cylinders a, b, and c in any one series. Now, since the method of inocula-

tion was different here, a having been ioculated with A. Vinelandii, b with a mixture of A. Vinelandii and a smaller motile bacillus, and c with A. Beyerincki; the differences in the inoculating material were without effect on the crop yields. Evidently the organisms introduced either failed to survive, or at least did not develop sufficiently to add any appreciable quantities of nitrogen to the soil. The presence of manure alone in series 17 and 18, and its presence with calcium carbonate in series 19, and with calcium carbonate and Thomas slag in series 20 did not apparently create conditions more favorable for the activities of the Azotobacter organisms. For instance, in series 18 the highest yield of nitrogen was 0.725 gms. in a, and the lowest 0.686 gms. in b. In the corresponding uninoculated series 8, the highest yield of nitrogen was 0.770 gms., and the lowest 0.619 gms., differences that are by no means conclusive. Similarly in the inoculated series 19, the highest yield of nitrogen was 0.674 gms. in c, and the lowest 0.580 gms. in b. In the corresponding uninoculated series 9 the yields were 0.926 gms. and 0.814 gms., both higher than the corresponding yields in series 19. This point is brought out more clearly in the following table giving the average yields in each series:

THE AVERAGE YIELD OF DRY MATTER AND OF NITROGEN.

Series.	Dry Matter. gms.	Nitrogen. gms.	Series.	Dry Matter. gms.	Nitrogen. gms.
1, ...	61.3	0.694	11, ...	57.6	0.639
2, ...	55.3	0.606	12, ...	67.6	0.746
3, ...	76.3	0.799	13, ...	67.3	0.724
4, ...	73.0	0.802	14, ...	64.3	0.681
5, ...	67.6	0.732	15, ...	66.3	0.724
6, ...	73.3	0.766	16, ...	65.0	0.694
7, ...	65.3	0.688	17, ...	66.0	0.712
8, ...	64.3	0.686	18, ...	64.6	0.711
9, ...	76.6	0.820	19, ...	58.6	0.636
10, ...	74.6	0.785	20, ...	64.3	0.742

It will be observed in the above tabulation that in the uninoculated series the application of lime in series 3 and 4 resulted in an increase of both dry matter and nitrogen over that in series 1 and 2 where nothing was applied. In series 5 and 6, where

Thomas slag was applied there was also an increase of dry matter and of nitrogen. In series 8, where manure was used at the rate of 15 tons per acre, the yield of dry matter and of nitrogen was not larger than that in series 7, where manure was applied at the rate of 10 tons per acre. The application of lime, together with the manure in series 9 led to a maximum yield of both dry matter and of nitrogen. Evidently the lime hastened the decomposition of the manure and of the soil humus, leading to a more intense ammonification and nitrification as has been repeatedly demonstrated in some of our experiments. In series 10, on the other hand, where Thomas slag was applied, in addition to the manure and the lime, there was no further increase either of dry matter or of nitrogen.

With two or three exceptions, the yields of dry matter and of nitrogen were smaller in the inoculated soils than they were in the corresponding uninoculated soils. The differences are more marked in series 3, 4, 6, 9 and 10. The average yield of dry matter was 68.8 for the uninoculated series and 64.2 gms. for the inoculated. The corresponding yields of nitrogen were 0.738 gms. and 0.701 gms., respectively. It is evident, therefore, that the oats crop of 1905 showed no benefit from the inoculation with Azotobacter in the preceding year. The organisms introduced at that time had either entirely disappeared or had found the soil conditions unfavorable for rapid increase in numbers and the fixation of atmospheric nitrogen. In order to test this matter further a small sample of soil was taken from each of the cylinders soon after the removal of the oats; the samples were secured with the usual precautions against contamination, placed in small, sterile boxes, and sent to the laboratory. Ten gram quantities of these soils were weighed off on the torsion balance, and placed in 100 cc. portions of a mannite solution made up in the customary manner. The several cultures were then placed in the incubator at 28° C and kept under observation for ten days. But few of the cultures developed characteristic Azotobacter membranes, among these 19c and 20c were particularly prominent. Both of these, it will be remembered, were inoculated with A. Beyerincki. The failure of the other inoculated soils to produce these membranes indicated that the

Azotobacter there had become enfeebled or had entirely disappeared. It appeared, furthermore, that in the uninoculated series the Azotobacter species had not become prominent spontaneously even though the conditions in some of the soils had been made favorable for their growth.

The analysis of the several mannite cultures at the end of 10 days showed the following:

NITROGEN IN THE MANNITE CULTURES.

Series.	Nitrogen. mgs.	Average. mgs.	Series.	Nitrogen. mgs.	Average. mgs.
1a, ...	8.87	....	11a, ...	9.69	....
b, ...	8.74	8.93	b, ...	9.31	9.27
c, ...	9.18	....	c, ...	8.80	....
2a, ...	8.74	....	12a, ...	9.63	....
b, ...	8.81	8.79	b, ...	9.37	9.50
c, ...	8.81	....	c, ...	Lost	....
3a, ...	9.12	....	13a, ...	9.37	....
b, ...	9.24	9.39	b, ...	10.00	10.23
c, ...	9.81	....	c, ...	11.32	....
4a, ...	9.69	....	14a, ...	9.43	....
b, ...	8.56	9.10	b, ...	10.12	10.96
c, ...	9.06	....	c, ...	13.33	....
5a, ...	Lost	....	15a, ...	9.94	....
b, ...	9.06	9.12	b, ...	9.69	9.96
c, ...	9.18	....	c, ...	10.25	....
6a, ...	9.18	....	16a, ...	9.88	....
b, ...	9.24	9.39	b, ...	10.18	9.85
c, ...	9.75	....	c, ...	9.49	....
7a, ...	8.93	....	17a, ...	9.63	....
b, ...	9.30	8.91	b, ...	9.63	9.67
c, ...	8.49	....	c, ...	9.75	....
8a, ...	9.18	....	18a, ...	10.63	....
b, ...	9.06	9.22	b, ...	10.25	10.31
c, ...	9.43	....	c, ...	10.06	....
9a, ...	9.63	....	19a, ...	10.75	....
b, ...	9.81	9.83	b, ...	11.26	13.12
c, ...	10.06	....	c, ...	17.36	....
10a, ...	9.63	....	20a, ...	10.87	....
b, ...	9.94	10.09	b, ...	11.70	12.89
c, ...	10.69	....	c, ...	16.10	....

In comparing the data in the above table it will be found that the culture solutions inoculated with the soils from series 11–20 contained in every case more nitrogen than did those inoculated

with the corresponding soils 1–10. Thus the average amount of nitrogen found in the cultures from series 1 was 8.93 mg., and in those from series 11, 9.27 mg. The corresponding amounts for series 2 and 12 were 8.79 mg. and 9.50 mg., respectively, and for series 3 and 13, 9.39 mg. and 10.23 mg., respectively. The differences are even more prominent in series 9 and 10 on the one hand, and 19 and 20 on the other.

A more detailed examination of the inoculated series shows a decided tendency for the soils from cylinders c towards a more pronounced nitrogen-fixing power. Thus the mannite solutions inoculated with soil 10 c contained the maximum amount of nitrogen for that series. The same is true of 13c, 14c, 15c, 19c and 20c. Now since the c cylinders in each of the inoculated series were supplied with A. Beyerincki it would appear that this Azotobacter species found conditions more favorable for its survival than did A. Vinelandii even though in the laboratory cultures the latter can produce twice as much combined nitrogen per gram of mannite consumed than is usually produced by A. Beyerincki. It seems, however, that A. Beyerincki not only survived, but retained its full power of nitrogen-fixation in at least two series 19 and 20. Now the latter had received applications both of manure and of lime, and it would appear thus that they furnished conditions favorable for the life processes of A. Beyerincki. At the same time, it must be concluded that in the b and a cylinders supplied with A. Vinelandii, the latter had not entirely disappeared, since there was an appreciable gain of nitrogen from the inoculated over the corresponding uninoculated soils. There are indications likewise that in several of the series the presence of the small bacillus, together with A. Vinelandii led to a somewhat more marked nitrogen-fixation. This applies to series 13, 14, 16, 19 and 20.

The Corn Crop, 1905.

After the removal of the oats crop and the sampling of the soils for inoculation into the mannite solutions, the cylinder soils were spaded up and seeded to corn. The germination was satis-

factory and the initial growth fairly good. The lack of nitrogen soon became strikingly apparent, however. The plants remained yellow and stunted, and beyond a certain point seemed to make no progress. Occasionally a plant occurred that was of a somewhat darker green than the others, and slightly larger in size. The plants in the inoculated series were to all appearance no better than the plants in the corresponding uninoculated series. The crop was harvested in September, and determinations of dry matter and of nitrogen were made in the usual way.

DRY MATTER AND NITROGEN IN THE CORN CROP, 1905.

Series.	Dry Matter. gms.	Nitrogen. %	Nitrogen. gms.	Series.	Dry Matter. gms.	Nitrogen. %	Nitrogen. gms.
1a, ...	52	0.983	0.511	11a, ...	59	0.979	0.578
b, ...	60	0.972	0.583	b, ...	60	0.966	0.580
c, ...	64	0.913	0.584	c, ...	60	1.013	0.608
2a, ...	48	0.958	0.460	12a, ...	53	0.989	0.524
b, ...	59	0.994	0.586	b, ...	52	0.955	0.497
c, ...	66	1.002	0.661	c, ...	53	0.910	0.482
3a, ...	52	1.060	0.551	13a, ...	46	0.992	0.456
b, ...	54	0.951	0.513	b, ...	50	0.941	0.470
c, ...	53	1.008	0.534	c, ...	52	0.941	0.489
4a, ...	53	0.990.	0.525	14a, ...	55	0.944	0.519
b, ...	57	0.956	0.545	b, ...	53	0.961	0.509
c, ...	64	1.136	0.727	c, ...	56	0.856	0.479
5a, ...	57	0.946	0.539	15a, ...	52	0.978	0.508
b, ...	61	1.006	0.614	b, ...	53	0.927	0.491
c, ...	53	0.935	0.495	c, ...	49	0.927	0.454
6a, ...	53	0.913	0.483	16a, ...	50	0.924	0.462
b, ...	56	0.899	0.503	b, ...	56	0.927	0.519
c, ...	53	0.930	0.492	c, ...	56	0.909	0.507
7a, ...	60	0.909	0.545	17a, ...	50	0.921	0.460
b, ...	61	0.919	0.560	b, ...	49	1.021	0.500
c, ...	61	0.931	0.568	c, ...	55	0.912	0.502
8a, ...	59	1.000	0.590	18a, ...	51	1.011	0.516
b, ...	67	0.870	0.583	b, ...	58	0.909	0.527
c, ...	63	0.972	0.612	c, ...	53	0.943	0.500
9a, ...	59	0.921	0.543	19a, ...	61	0.921	0.561
b, ...	51	0.942	0.480	b, ...	64	0.943	0.621
c, ...	59	0.897	0.529	c, ...	58	0.926	0.537
10a, ...	56	1.013	0.567	20a, ...	64	0.960	0.614
b, ...	66	0.969	0.639	b, ...	61	1.004	0.612
c, ...	76	0.920	0.699	c, ...	65	0.885	0.575

According to the data presented above, the maximum yield of dry matter was secured in 10c, and the maximum yield of nitrogen in 4c. Neither of these soils was inoculated. The other data in the table also fail to disclose any positive effect of the inoculation, as will appear more readily from the average yields of dry matter and of nitrogen presented below:

THE AVERAGE YIELDS OF DRY MATTER AND OF NITROGEN IN THE CORN CROP, 1905.

Series.	Dry Matter. gms.	Nitrogen. gms.	Series.	Dry Matter. gms.	Nitrogen. gms.
1,	58.7	0.559	11,	59.7	0.589
2,	57.7	0.569	12,	52.7	0.501
3,	53.0	0.533	13,	49.3	0.472
4,	58.0	0.599	14,	54.7	0.502
5,	57.0	0.549	15,	51.3	0.484
6,	54.0	0.493	16,	54.0	0.496
7,	60.7	0.558	17,	51.3	0.487
8,	63.0	0.595	18,	54.0	0.514
9,	56.3	0.517	19,	61.0	0.573
10,	66.0	0.635	20,	63.3	0.600

The average yields of dry matter still show in some of the series the influence of previous treatment. This is apparent in series 7 and 8 where manure was applied to the soils, and likewise in series 10, where manure, lime and Thomas slag were applied. Similarly in series 19 and 20 of the inoculated soils the yields were still larger than those in the other series, on account of the treatment in the spring of 1904. In the case of the nitrogen, also, the maximum yields were secured in series 10 and 20, respectively, showing that the influence of the combined manure, lime and Thomas slag treatment still persisted. As to the influence of the Azotobacter inoculation, we note that seven out of the ten uninoculated series produced more dry matter and more nitrogen than did the corresponding inoculated series. The differences in favor of the uninoculated series are most marked in series 3, 4, 5, 7 and 8. The total yield of dry matter in the ten uninoculated series was 584.4 gms., and in the ten inoculated series 551.3 gms. The total yield of nitrogen in the ten inoculated series was 5.607 gms., and in the ten uninoculated series 5.218 gms. It is clear, therefore, that also in the corn crop of 1905 the influence of inoculation on the nitrogen supply to the plants was not apparent.

After the removal of the corn in September, 1905, the soil in the several cylinders was spaded up, and rye seeded. One hundred grains were placed in each soil. The germination was normal, and the growth in the fall more or less considerable. In the following spring differences in the growth of the rye appeared as due to soil treatment in 1904. More plant substance was evidently being produced in series 4, 9, 10, 13, 14, 19 and 20 than in any of the other series. Now, series 4, 13 and 14 received applications of lime in 1904, and its influence was still felt in the spring of 1906. Series 9 and 10, and 19 and 20, received in 1904 applications of both lime and manure, and the influence of these applications still persisted two year later. Insofar as the influence of the inoculation was concerned, there was no marked differences appearing between the uninoculated and the inoculated series, although the latter seemed to be slightly superior to the former.

On May 18, the rye in the several series was harvested, weighed, cut into small pieces and incorporated in each case, with the soil of the corresponding cylinder.

WEIGHTS OF GREEN RYE, 1905-1906.

Series.	gms.	Series.	gms.	Series.	gms.	Average. gms.
1a,	50	1b,	24	1c,	7,	27.0
2a,	29	2b,	7	2c,	29,	21.7
3a,	9	3b,	115	3c,	114,	79.3
4a,	127	4b,	139	4c,	165,	143.7
5a,	39	5b,	35	5c,	55,	43.0
6a,	32	6b,	94	6c,	110,	78.7
7a,	26	7b,	10	7c,	9,	15.0
8a,	9	8b,	40	8c,	55,	34.7
9a,	177	9b,	168	9c,	187,	177.3
10a,	198	10b,	213	10c,	299,	236.7
11a,	50	11b,	25	11c,	30,	35.0
12a,	44	12b,	38	12c,	80,	54.0
13a,	131	13b,	144	13c,	140,	138.3
14a,	153	14b,	175	14c,	182,	170.0
15a,	20	15b,	47	15c,	88,	51.7
16a,	97	16b,	96	16c,	122,	105.0
17a,	61	17b,	54	17c,	90,	68.3
18a,	68	18b,	68	18c,	111,	82.3
19a,	187	19b,	218	19c,	195,	200.0
20a,	226	20b,	167	20c,	210,	201.0

It will be noted that the yields in the different series were somewhat irregular. For example, in series 1 the yield was 50 gms. in a, 24 gms. in b, and only 7 gms. in c. The yields were even more irregular in series 3; namely, 9 gms. in a, 115 gms. in b, and 114 gms. in c. These irregularities were due to a great extent to the winter-killing of some of the feeble plants in the series in question.

In comparing the average yields in the uninoculated series we note that in series 3, where each soil had received 28.80 gms. of calcium carbonate, the amount of plant substance produced was 79.3 gms. as against 21.7 gms. in series 2, and 27.0 gms. in series 1. In series 4, where double the amount of calcium carbonate was applied, namely, 57.60 gms., the amount of plant substance produced was 143.7 gms. Again, in series 5, with 14.40 gms. of Thomas slag, the average yield was 43.0 gms., while in series 6, with 28.80 gms. of Thomas slag, the average yield was 78.7 gms. The larger yield in series 6 was probably due not so much to the phosphoric acid as to the lime present in the slag. In series 7, where 576.07 gms. of manure had been applied in 1904, the average yield was quite small, only 15 gms., showing that the residual effect of the manure was quite slight in 1906. In series 8, with the larger application of manure, the yield was 34.7 gms., which is comparatively small. On the other hand, in series 9, where both lime and manure were used, the average yield was 177.3 gms., a considerable increase over series 4, where lime alone was employed. In series 10, where Thomas slag was added to the manure and lime, the production of plant substance was still larger, namely, 236.7 gms. It seems, therefore, that the lime treatment of 1904 was an important factor in determining the yields of rye in 1906, a factor of greater significance than either the manure or the Thomas slag. Similar relations to those just quoted occur also in the inoculated series 11–20, thus confirming the facts already brought out.

As to the effect of the inoculations in 1904, we note here some distinctly positive results. In series 11 the yield was 35.0 gms. as against 27 gms. in the uninoculated series 1. The corresponding figures in 12 and 2 were 54 gms. and 21.7 gms., respectively. The same may be said of all of the other series

with the exception of series 20, where the yield was lower than that in the corresponding uninoculated series. The increase of the inoculated over the uninoculated was 32.3 gms. in the case of series 2 and 12; 59 gms. in the case of series 3 and 13; 26.3 gms. in the case of series 4 and 14; 26.3 gms. in the case of series 6 and 16; 53.3 gms. in the case of series 7 and 17; and 47.6 gms. in the case of series 8 and 18.

How is the practically uniform superiority of the inoculated over the uninoculated series to be accounted for? The methods of soil treatment were the same for the two with the exception of the inoculation. The amounts and quality of the lime, manure and Thomas slag were the same; the temperature and moisture conditions were the same. The conclusion is almost inevitable that the Azotobacter organisms introduced two years previously had in some way increased in numbers under the rye crop and had produced in the soil appreciable quantities of combined nitrogen. There may, of course, have been other factors which produced the results in question; if so, they are still to be discovered. It would seem almost that there is an important relation between the crops and the soil flora, and that the different groups of soil bacteria are not influenced equally by any one particular crop. It would be worth while to remember in this place that the green weights recorded above, and the differences which they show, do not necessarily involve corresponding differences in the nitrogen content of the crops.

A few days after the green rye was turned under, the several cylinder soils were seeded to corn. In the case of series 11–20 each kernel of corn was dipped into a mannite solution of A. Vinelandii. Otherwise the soils received no treatment. The germination was, on the whole, satisfactory. The young plants began to show early a lack of nitrogen, remained stunted and yellow throughout the growing season, and formed no ears. The crop was harvested in September, dried, ground and analyzed.

THE YIELD AND COMPOSITION OF THE CORN CROP, 1906.

Series.	Dry Matter. gms.	Nitrogen. %	Nitrogen. gms.	Series.	Dry Matter. gms.	Nitrogen. %	Nitrogen. gms.
1a, ...	119	0.605	0.720	11a, ...	133	0.556	0.739
b, ...	134	0.519	0.695	b, ...	131	0.484	0.634
c, ...	115	0.604	0.695	c, ...	110	0.645	0.709
2a, ...	128	0.656	0.840	12a, ...	122	0.555	0.677
b, ...	133	0.564	0.750	b, ...	131	0.521	0.682
c, ...	138	0.539	0.743	c, ...	116	0.577	0.669
3a, ...	161	0.522	0.840	13a, ...	119	0.559	0.665
b, ...	124	0.536	0.665	b, ...	115	0.525	0.604
c, ...	117	0.600	0.702	c, ...	107	0.569	0.609
4a, ...	119	0.555	0.660	14a, ...	119	0.533	0.634
b, ...	124	0.556	0.689	b, ...	114	0.542	0.618
c, ...	113	0.553	0.625	c, ...	106	0.560	0.594
5a, ...	145	0.531	0.770	15a, ...	134	0.529	0.709
b, ...	146	0.630	0.920	b, ...	131	0.512	0.671
c, ...	131	0.535	0.701	c, ...	119	0.547	0.651
6a, ...	146	0.527	0.769	16a, ...	122	0.512	0.625
b, ...	129	0.545	0.703	b, ...	124	0.529	0.656
c, ...	137	0.547	0.749	c, ...	116	0.567	0.658
7a, ...	141	0.526	0.742	17a, ...	113	0.570	0.644
b, ...	172	0.489	0.841	b, ...	134	0.519	0.695
c, ...	179	0.500	0.895	c, ...	123	0.539	0.663
8a, ...	160	0.523	0.837	18a, ...	130	0.550	0.715
b, ...	144	0.534	0.769	b, ...	124	0.564	0.699
c, ...	165	0.581	0.959	c, ...	114	0.594	0.677
9a, ...	119	0.538	0.640	19a, ...	108	0.520	0.561
b, ...	120	0.532	0.638	b, ...	109	0.583	0.635
c, ...	133	0.644	0.756	c, ...	104	0.578	0.601
10a, ...	120	0.554	0.665	20a, ...	113	0.608	0.677
b, ...	137	0.500	0.685	b, ...	109	0.562	0.612
c, ...	142	0.627	0.890	c, ...	109	0.591	0.644

With very few exceptions the yields of dry matter and of nitrogen were higher in the uninoculated series than they were in the corresponding inoculated series. In some instances the differences in favor of the former are quite considerable. Thus in 2a, 3a, 5b, 7b, 8c, 10c, etc., the yields of nitrogen are very appreciably larger than in the corresponding inoculated series. The explanation for these differences must be sought, apparently, in the larger yields of rye secured in the inoculated series. It must be assumed that this crop used up much of the nitrogen made available during the preceding fall and winter, leaving

thus a smaller store of it for the corn crop which succeeded it. It is evident, of course, that the available nitrogen compounds were utilized more thoroughly where the rye crop was most vigorous, and the corresponding soils were, therefore, less able to supply the nitrogen requirements of the corn than the other soils, whose rye crop was smaller. For example, the weight of the rye in 3a was 9 gms., while in 3b and 3c it was 115 gms. and 114 gms., respectively. The dry weight of the corn was 161 gms. in 3a, and 124 gms. and 117 gms., respectively, in 3b and 3c. Similarly in 4c, the yield of rye was high and the yield of corn low; the same may be said of 7a, 10a, 12c, 14c, 16c and 18c. The influence of the rye crop on the corn crop is more clearly apparent in the following table where the average yields of dry matter and of nitrogen in the corn crop are given.

THE AVERAGE YIELDS OF DRY MATTER AND OF NITROGEN IN THE CORN CROP, 1906.

Series.	Dry Matter. gms.	Nitrogen. gms.	Series.	Dry Matter. gms.	Nitrogen. gms.
1, ...	122.7	0.703	11, ...	124.7	0.694
2, ...	133.0	0.778	12, ...	123.0	0.683
3, ...	134.0	0.736	13, ...	113.7	0.626
4, ...	118.7	0.658	14, ...	113.0	0.615
5, ...	140.7	0.797	15, ...	128.0	0.677
6, ...	137.3	0.740	16, ...	120.7	0.646
7, ...	164.0	0.826	17, ...	123.3	0.667
8, ...	156.3	0.854	18, ...	122.7	0.697
9, ...	124.0	0.678	19, ...	107.0	0.599
10, ...	133.0	0.747	20, ...	110.3	0.644

The average yields of dry matter show that in series 4 the yield of rye was 143.7 gms., and the yield of corn 118.7 gms.; whereas, in series 3 the yield of rye was 79.3 gms. and the yield of corn 134 gms. Again, in series 7 the yield of rye was 15 gms. and the yield of corn 164 gms. In series 10 the yield of rye was 236.7 gms. and the yield of corn 133 gms. Now, comparing the uninoculated with the inoculated series, we find the following. In series 2 and 12, respctively, the yields of rye were 21.7 gms. and 54.0 gms. The corresponding yields of corn were 133.0 gms. and 123.0 gms. In series 3 and 13, respectively, the yields of rye were 79.3 gms. and 138.3 gms., while

the corresponding yields of corn were 134.0 gms. and 113.7 gms. With one or two exceptions the same relations occur in all of the other series.

It should be remembered that the rye was again returned to the soil, and with it the nitrogen contained in its substance. Notwithstanding this return of the nitrogen to the soil, the following crop failed to secure a large portion of it on account of the slow decomposition of the rye. Something may be attributed, also, to the retarded nitrification in the soils where the larger rye crops had removed large quantities of moisture. For the same reason the yield of dry matter in the corn crop in series 3, where the single quantity of calcium carbonate had been applied, was 134.0 gms., and in series 4, where the double quantity had been applied, only 118.7 gms. Similarly, in series 5, where the single quantity of Thomas slag had been applied, the yield of dry matter in the corn crop was 140.7 gms., and in series 6, where the double quantity had been applied, it was 137.3 gms. In series 7, with an application of 576.07 gms. of manure, the yield of dry matter in the corn crop was 164.0 gms., and in series 8, with an application of 864.10 gms. of manure the yield was 156.3 gms. The yields of nitrogen correspond, in most instances, to those of the dry matter in both the inoculated and the uninoculated series.

These results all show how unsafe it is to judge of the effects of inoculation, or of the effects of any method of soil treatment by a single season's crop. Differences in moisture conditions, temperature conditions, or in chemical and bacteriological conditions in the preceding season may, among other things, exert a marked effect on crop growth, an effect which may be more or less apparent for several seasons.

Yields of Green Rye, 1906-1907.

After the removal of the corn crop carbon bisulphide at the rate of 100 gms. per cylinder was applied in 11–20b and 11–20c. The soils in the several cylinders were then spaded up and seeded to rye as in the preceding year, 100 seeds being employed in each case. The germination was poor, and some of the plants were killed by the frosts of the following winter. In some of

the cylinders only two or three plants survived in the spring. The green weights of the rye were as follows:

Series.	1906. gms.	1907. gms.	Series.	1906. gms.	1907. gms.
1a,	50	8	11b,	25	1
2a,	29	24	12b,	38	25
3a,	9	1	13b,	144	162
4a,	127	137	14b,	175	121
5a,	39	7	15b,	47	25
6a,	32	14	16b,	96	5
7a,	26	5	17b,	54	14
8a,	9	2	18b,	68	1
9a,	177	164	19b,	218	187
10a,	198	170	20b,	167	185
11a,	50	9	1c,	7	23
12a,	44	7	2c,	29	10
13a,	131	103	3c,	114	109
14a,	153	137	4c,	165	81
15a,	20	1	5c,	55	70
16a,	97	95	6c,	110	77
17a,	61	45	7c,	9	1
18a,	68	6	8c,	55	21
19a,	187	135	9c,	187	187
20a,	226	120	10c,	299	180
1b,	24	14	11c,	30	30
2b,	7	2	12c,	80	29
3b,	115	91	13c,	140	102
4b,	139	155	14c,	182	142
5b,	35	25	15c,	88	29
6b,	94	72	16c,	122	9
7b,	10	20	17c,	90	20
8b,	40	27	18c,	111	4
9b,	168	140	19c,	195	132
10b,	213	169	20c,	210	122

The influence of the carbon bisulphide is not uniformly apparent in these yields, as may be seen by comparing the results in series 11–20a, 11–20b and 11–20c.

It will be seen, futhermore, that on the whole the yields of 1906, inserted here for comparison, are superior to those of 1907 in nearly every instance. At the same time, the influence of soil treatment in 1904 is apparent also in the rye crop of 1907. This is brought out more graphically in the following tabulation giving the average yields for each series:

THE AVERAGE WEIGHTS OF GREEN RYE.

Series.	1906. gms.	1907. gms.	Series.	1906. gms.	1907. gms.
1, ...	27.0	15.0	11, ...	35.0	13.3
2, ...	21.7	12.0	12, ...	54.0	20.3
3, ...	79.3	67.0	13, ...	138.3	122.3
4, ...	143.7	124.3	14, ...	170.0	133.3
5, ...	43.0	34.0	15, ...	51.7	18.3
6, ...	78.7	54.3	16, ...	105.0	36.3
7, ...	15.0	8.7	17, ...	68.3	26.3
8, ...	34.7	16.7	18, ...	82.3	3.7
9, ...	177.3	163.7	19, ...	200.0	151.3
10, ...	236.7	173.0	20, ...	201.0	142.3

In 1907, as in 1906, the influence of the lime treatment in 1904 was still felt. In series 3, where the single quantity of lime was applied the yield was 67.0 gms., while in series 4, where the double quantity of lime was applied, the yield was 124.3 gms. In series 5, where the single quantity of Thomas slag was applied, the yield was 34.0 gms.; while in series 6, where the double quantity of Thomas slag was applied the yield was 54.3 gms. The yields in series 7 and 8, respectively, where the single and double quantities of manure were applied, were small; while in series 9 and 10, where the manure was used together with lime, or with lime and Thomas slag, the yields were quite considerable. We see again, therefore, that lime more than manure exterted a favorable influence, three years after its application, on the growth of the rye. In the parallel inoculated series 13, 14, 15 and 16, the relations were very similar. Thus the weight of the rye in series 3 was 122.3 gms., and in series 4,133.3 gms.; in series 5, 18.3 gms., and in series 6, 36.3 gms. The effect of the inoculation itself was no longer as marked in 1907 as it was in 1906, although in one or two instances there was some apparent influence there. This applies to series 2 and 12, 3 and 13, and 4 and 14.

The Corn Crop, 1907.

Corn was again seeded in the cylinder soils after the green rye was turned under. As in the preceding season the seed of series 11–20 was inoculated with a vigorous culture of A. Vinelandii.

The germination was satisfactory throughout, but, as was the case in 1906, the lack of available nitrogen in the soil soon became quite evident. Series 11–20b, and 11–20c, which had been treated with carbon bisulphide were not apparently better able to support the corn crop than were series 11–20a.

THE YIELDS AND COMPOSITION OF THE CORN CROP, 1907.

Series.	Dry Matter. gms.	Nitrogen. %	Nitrogen. gms.	Series.	Dry Matter. gms.	Nitrogen. %	Nitrogen. gms.
1a, ...	87	0.651	0.566	11a, ...	110	0.652	0.717
b, ...	93	0.730	0.679	b, ...	151	0.620	0.936
c, ...	94	0.739	0.694	c, ...	172	0.634	1.090
2a, ...	102	0.748	0.763	12a, ...	119	0.629	0.748
b, ...	132	0.700	0.924	b, ...	149	0.586	0.873
c, ...	119	0.699	0.832	c, ...	149	0.612	0.912
3a, ...	110	0.829	0.912	13a, ...	130	0.652	0.848
b, ...	138	0.613	0.846	b, ...	126	0.516	0.650
c, ...	111	0.697	0.774	c, ...	149	0.573	0.854
4a, ...	110	0.585	0.643	14a, ...	95	0.638	0.606
b, ...	124	0.619	0.767	b, ...	128	0.547	0.717
c, ...	114	0.641	0.731	c, ...	99	0.648	0.641
5a, ...	103	0.690	0.711	15a, ...	117	0.643	0.752
b, ...	115	0.664	0.764	b, ...	156	0.612	1.015
c, ...	119	0.733	0.872	c, ...	152	0.594	0.903
6a, ...	92	0.735	0.676	16a, ...	91	0.625	0.569
b, ...	129	0.619	0.798	b, ...	172	0.568	0.977
c, ...	130	0.646	0.840	c, ...	166	0.587	0.974
7a, ...	98	0.706	0.621	17a, ...	96	0.620	0.595
b, ...	136	0.617	0.839	b, ...	160	0.553	0.885
c, ...	112	0.714	0.800	c, ...	159	0.577	0.917
8a, ...	112	0.714	0.800	18a, ...	111	0.610	0.677
b, ...	128	0.643	0.823	b, ...	164	0.594	0.974
c, ...	155	0.673	1.044	c, ...	164	0.565	0.927
9a, ...	108	0.539	0.582	19a, ...	89	0.591	0.526
b, ...	129	0.561	0.724	b, ...	116	0.577	0.669
c, ...	121	0.626	0.757	c, ...	108	0.568	0.613
10a, ...	96	0.636	0.611	20a, ...	113	0.542	0.612
b, ...	123	0.587	0.722	b, ...	96	0.594	0.570
c, ...	187	0.627	1.172	c, ...	116	0.582	0.675

The weights of the dry matter recorded in the above table seem to have been affected by the application of carbon bisulphide in the preceding season. At any rate, we find that in a

number of the a cylinders the yields of dry matter are smaller than those in the corresponding b and c cylinders. This applies to series 11, 12, 13, 14, 15, 16, 17, 18 and 19. The fact cannot be overlooked, however, that also in series 1–10, which had not been treated with carbon bisulphide, the yields of dry matter in the a cylinders are smaller than those in the corresponding b and c cylinders. For this reason the differences in series 11–20 cannot be ascribed definitely to the carbon bisulphide treatment. The nitrogen yields show variations much like those in the yields of dry matter. This may be readily ascertained by a comparison of the data in the table. In series 1, for example, the yields of nitrogen in the a, b and c cylinders, respectively, were 0.566 gms., 0.679 gms. and 0.694 gms. The corresponding figures in series 2 were 0.763 gms., 0.924 gms. and 0.832 gms.; in series 4, 0.643 gms., 0.767 gms. and 0.731 gms.; in series 5, 0.711 gms., 0.764 gms. and 0.872 gms., etc. Like relations in the nitrogen yields are shown in series 11–20, with the exception that the differences between the a cylinders on the one hand and the b and c cylinders on the other are somewhat greater. The average yield of nitrogen for the a cylinders in series 1–10 was 0.688 gms., and for the b and c series 0.820 gms. A decided difference is shown thus in favor of soils b and c. In like manner the a cylinders in series 11–20 showed an average yield of 0.665 gms., while the b and c cylinders showed an average yield of 0.839 gms. of nitrogen. Notwithstanding these differences, it would hardly be safe to assume that the carbon bisulphide was instrumental in determining the results secured. As to the effect of the inoculation with A. Vinelandii, it was, if anything, negative. This was already brought out in the comparison of the average yields of nitrogen in the a cylinders of series 1–10, as against the a cylinders of series 11–20. As to the influence of the soil treatment in 1904, on the yields of dry matter and of nitrogen, the corn crop of 1907 does not show it to such an extent as did the two rye crops. This fact is shown more clearly in the following tabulation giving the average yields in the several series:

THE AVERAGE YIELDS OF DRY MATTER AND OF NITROGEN IN THE CORN CROP, 1907.

Series.	Dry Matter. gms.	Nitrogen. gms.	Series.	gms. Dry Matter.	gms. Nitrogen.
1, ...	91.3	0.646	11, ...	144.3	0.914
2, ...	117.7	0.840	12, ...	139.0	0.844
3, ...	119.7	0.844	13, ...	135.0	0.784
4, ...	116.0	0.714	14, ...	107.3	0.655
5, ...	112.3	0.782	15, ...	141.7	0.890
6, ...	117.0	0.771	16, ...	143.0	0.840
7, ...	115.3	0.753	17, ...	138.3	0.799
8, ...	131.7	0.889	18, ...	146.3	0.859
9, ...	119.3	0.688	19, ...	104.3	0.603
10, ...	135.3	0.835	20, ...	108.3	0.619

The figures presented above show the influence of the various applications in 1904, although this influence had evidently been modified by the intervening crops. The weight of the dry matter in series 3 was, on the average, 119.7 gms. as against 116.0 gms. in series 4. It will be remembered that these series received 28.80 gms. and 57.60 gms., respectively, of calcium carbonate. The single and double applications of Thomas slag were similarly reflected in the yields of series 5 and 6; the applications of manure alone in series 7 and 8; and the applications of manure and lime, or of manure, lime and Thomas slag in series 9 and 10. Attention should be called here, particularly, to the very considerable yield of dry matter and of nitrogen in series 8, which had received the double application of manure. The influence of the latter was still felt, apparently, three years after its application. In the inoculated series 11–20 the relations were quite similar, although rather less pronounced in some instances. It may not be amiss also to point out here that the yields in series 19 and 20 were considerably lower than in series 9 and 10.

THE TOTAL AVERAGE YIELDS OF DRY MATTER IN 1905, 1906 AND 1907.

In taking the total average yields of dry matter produced in the one oats crop and the three corn crops we find the following:

Series.	1905. gms.	1906. gms.	1907. gms.	Total. gms.	Series.	1905. gms.	1906. gms.	1907. gms.	Total. gms.
1, ...	120.0	122.7	91.3	334.0	11, ...	117.3	124.7	144.3	386.3
2, ...	113.0	133.0	117.7	363.7	12, ...	120.3	123.0	139.0	382.3
3, ...	129.3	134.0	119.7	383.0	13, ...	116.0	113.7	135.0	364.7
4, ...	131.0	118.7	116.0	365.7	14, ...	119.0	113.0	107.3	339.3
5, ...	124.6	140.7	112.3	377.6	15, ...	117.6	128.0	141.7	387.3
6, ...	127.3	137.3	117.0	381.6	16, ...	119.0	120.7	143.0	382.7
7, ...	126.0	164.0	115.3	405.3	17, ...	117.3	123.3	138.3	378.9
8, ...	127.3	156.3	131.7	415.3	18, ...	118.6	122.7	146.3	387.6
9, ...	132.9	124.0	119.3	376.2	19, ...	119.6	107.0	104.3	330.9
10, ...	140.6	133.0	135.3	408.9	20, ...	127.6	110.3	108.3	346.2

It is evident from the tabulated yields that the increase from the untreated to the treated soils is not very large in any case. In the uninoculated series we find the minimum yield of dry matter in series 1, namely, 334.0 gms., and the maximum yield in series 8, namely, 415.3 gms., an increase of 81.3 gms., or 24.3%. In the inoculated series 11–20 the minimum total yield occurred in series 19, and the maximum total yield in series 18, the difference between the two was 55.7 gms., or 16.8%. The maximum yield was secured in each instance in the soils that had received an application of manure at the rate of 15 tons per acre, and the increase must be considered rather small for a soil deficient in available nitrogen compounds. It should be noted, further, that in both series 4 and 14, which had received the double application of calcium carbonate, the yields of dry matter were smaller than those in the corresponding series 3 and 13, which had received the single application of calcium carbonate. The smaller yields from the larger applications of lime were due, perhaps, to the same cause, which was responsible for the comparatively slight increase from the manure, namely, the more intense ammonification and nitrification during the first summer, when the soils were kept bare, and the consequent loss of nitrates by leaching. Moreover, in series 9, where the larger application of manure was employed together with lime, the yield of dry matter was markedly smaller than that in series 8, where manure without lime was used. The same is true in series 18 and 19, respectively. In series 10, where Thomas slag was used, together with the manure and lime, the yield of dry matter was larger than that in series 9, though still smaller than that in 8. This applies also

to series 20. It is not impossible, of course, that the depressing influence of the lime was due to physiological causes, although no direct evidence in this direction can be supplied from the data at hand.

In comparing the yields of dry matter from the uninoculated series with those from the corresponding inoculated series, we find the latter lower than the former. This applies to series 3 and 13; 4 and 14; 7 and 17; 8 and 18; 9 and 19; 10 and 20. It may also be noted here that in the inoculated series 11–20 the yields of 1907 were at times larger than those of 1906, and the latter larger than those of 1905. We find this to be the case in series 11, where the yields for 1905, 1906 and 1907 were 117.3 gms., 124.7 gms. and 144.3 gms., respectively. An analogous increase may be noted in series 12, 15, 16, 17, 18. To some extent, perhaps, the treatment with carbon bisulphide may have contributed to the larger yields of 1907, a fact already noted in the preceding pages.

A better measure of the effect exerted by the different methods of soil treatment may be found in the average yields of nitrogen, since the latter may be safely regarded as the controlling factor of growth in the cylinder soils under experiment.

THE TOTAL AVERAGE YIELDS OF NITROGEN IN 1905, 1906 AND 1907.

Series.	1905.	1906.	1907.	Total.	Series.	1905.	1906.	1907.	Total.
1, ...	1.253	0.703	0.646	2.602	11, ...	1.228	0.694	0.914	2.836
2, ...	1.175	0.778	0.840	2.793	12, ...	1.247	0.683	0.844	2.774
3, ...	1.332	0.736	0.844	2.912	13, ...	1.196	0.626	0.784	2.606
4, ...	1.401	0.658	0.714	2.773	14, ...	1.183	0.615	0.655	2.453
5, ...	1.281	0.797	0.782	2.860	15, ...	1.208	0.677	0.890	2.775
6, ...	1.259	0.740	0.771	2.770	16, ...	1.190	0.646	0.840	2.776
7, ...	1.246	0.826	0.753	2.825	17, ...	1.199	0.667	0.799	2.665
8, ...	1.281	0.854	0.889	3.024	18, ...	1.225	0.697	0.859	2.781
9, ...	1.337	0.678	0.688	2.703	19, ...	1.209	0.594	0.603	2.406
10, ...	1.420	0.747	0.835	3.002	20, ...	1.342	0.644	0.619	2.605

The nitrogen yields of 1905 were larger than those of 1906 and of 1907 on account of the partial accumulation of nitrogen compounds in the fallow soils of the preceding year, and likewise on account of the fact that two crops instead of one were removed

from the cylinder soils in 1905. The influence of the soil treatment in 1904 may be readily traced in the nitrogen yields of 1905. Thus in series 3 and 4, which had received applications of calcium carbonate the yields were larger than those in the untreated series 1 and 2. The influence of the Thomas slag in series 5 and 6, and of the manure in series 7 and 8 is not as pronounced. The influence of the manure and lime in series 9, and of the manure, lime and Thomas slag in series 10, is again quite marked. In the parallel inoculated series 11–20, we note a depression instead of a gain from the lime treatment in series 13 and 14. In fact, all of the treated soils, with the exception of those in series 20, produced smaller yields than did the untreated soils 11 and 12. In 1906, the largest yields of nitrogen were secured in series 8, which received the double portion of manure, series 7, which had received the single portion of manure, and series 5, which had received the single portion of Thomas slag. In 1907, the largest yields in the uninoculated soils, were secured in series 8, which had received the double portion of manure, series 3, which had received the single portion of lime, in series 2, which received nothing, and in series 10, which received manure, lime and Thomas slag. In the inoculated series the largest yields of nitrogen were secured, in 1907, in series 11, 15, 18 and 12. The total yields for the three years show series 8, 10, 3 and 5 to be in the lead, all of them averaging more than 2.850 gms. of nitrogen. In the inoculated series 11–20, on the other hand, series 11 alone, exceeded an average yields of 2.800. Taking the sum of the averages for series 1–10, we find a total nitrogen yield of 28.62 gms. for series 1–10; and of 26.68 gms. for series 11–20. It is clear, therefore, that neither the repeated inoculation with Azotobacter, nor the treatment with carbon bisulphide enabled the soils of series 11–20 to produce more nitrogen in the crops than was produced in the uninoculated series 1–10.

THE NITROGEN BALANCE IN THE CYLINDER SOILS.

Series.	1904. gms.	1907. gms.	Removed in the Crops. gms.	Gain or Loss. gms.	Series.	1904. gms.	1907. gms.	Removed in the Crops. gms.	Gain or Loss. gms.
1, ...	71.17	66.84	2.602	—1.73	11, ...	71.17	68.83	2.836	+0.50
2, ...	71.17	70.82	2.793	+2.44	12, ...	71.17	66.84	2.774	—1.56
3, ...	71.17	71.27	2.912	+3.01	13, ...	71.17	70.23	2.606	+1.67
4, ...	71.17	69.63	2.773	+1.23	14, ...	71.17	69.43	2.453	+0.71
5, ...	71.17	69.83	2.860	+1.52	15, ...	71.17	66.90	2.775	—1.50
6, ...	71.17	68.17	2.770	—0.23	16, ...	71.17	67.74	2.776	—0.65
7, ...	71.17	71.49	2.825	+3.44	17, ...	71.17	71.12	2.665	+2.61
8, ...	71.17	68.66	3.024	+0.51	18, ...	71.17	71.82	2.781	+2.83
9, ...	71.17	68.83	2.703	+0.36	19, ...	71.17	68.83	2.406	+0.07
10, ...	71.17	71.03	3.002	+2.86	20. ...	71.17	69.50	2.605	+0.93

The analytical data presented in the above table show the nitrogen content of the cylinder soils at the beginning of the experiment in 1904, and also that of the soils in the fall of 1907. The samples of 1907 were secured by means of a soil-sampling tube. Three cores were taken in each cylinder, making in all nine cores for three cylinders in each series. The soil thus secured was thoroughly mixed and subsampled, the samples removed to the laboratory, dried, ground and analyzed for total nitrogen. Twenty grams of soil were weighed off for digestion, and four samples were taken of each soil. It was aimed to secure at least three determinations that would agree within 0.1 cc. tenth normal acid.

It will be noted that the analyses of 1907 show in most cases a more or less marked gain of nitrogen over those of 1904. Allowing 1 gram of nitrogen as within the limit of error, we find that in series 2, 3, 4, 5, 7, 10, 13, 17 and 18, the gain was quite distinct. From the standpoint of soil treatment in 1904, series 3 and 4, where lime was applied had apparently gained very appreciable quantities of nitrogen by 1907. The gain in series 5 and 6, where Thomas slag was applied, was smaller, in fact, there was a slight loss in 6. Attention should also be called here to the comparatively large gain in series 7, where the single quantity of manure was used; and likewise in series 10, where manure, lime and Thomas slag were used together. In the inoculated

series 11–20, the gains were less pronounced, but were most marked in series 13, 17 and 18. On the other hand, some of the series showed distinct losses of nitrogen, notably series 1, 12 and 15.

In considering the losses and gains of nitrogen in the cylinder soils, the fact should not be overlooked that a certain amount of nitrogen was added to the soil in the rain and snow, a quantity which may be estimated at 0.5 gm. for the three seasons. Moreover, the seed of the oats, rye and corn contained probably about 1.0 gm. of nitrogen. Subtracting these additions from the gains of nitrogen noted, we find that the latter are thus reduced to a very appreciable extent. On the other hand, more or less extensive losses must have occurred by the leaching of the soluble nitrates into the subsoil, and it is not impossible that in the decomposition of the organic matter in the soil some nitrogen was lost by its escape in the elementary state.

Summary.

From all the facts before us, it does not appear that inoculation with Azotobacter had, under the conditions of the experiment, increased the nitrogen resources of the soil. It is possible that with larger amounts of humus in the soil the nitrogen-fixing organisms would have found better conditions for their survival and rapid development. There are indications also that Azotobacter Beyerincki and Azotobacter chroococcum might have accomplished more in the inoculated soils than did A. Vinelandii even though the latter is endowed with a greater power of nitrogen-fixation in the laboratory. At any rate the mannite cultures prepared from the soils in 1905, a year subsequent to the inoculation, showed characteristics Azotobacter membranes only in some of the c cylinders. This taken in connection with the fact that A. Beyerincki and A. chroococcum are more frequently encountered than A. Vinelandii in the soils in the vicinity of New Brunswick may justify the belief just expressed. On the whole, the experiments presented here do not prove that inoculation with Azotobacter must al-

ways remain impracticable. They do show, however, that these organisms will not survive, or will not remain prominent in soils which do not offer suitable conditions for their growth, and future experiments must be directed towards a better understanding of these suitable conditions.

Bacteriological Studies of Madison Soil.

In the mid-summer of 1906, the Station was requested to examine a sample of soil from a garden owned by F. A. Seaman, at Madison, N. J. The laboratory examination of the sample showed the soil to be in good mechanical condition, and abundantly provided with lime and with nitrogen. The statement accompanying the sample indicated that the bacteriological condition of the soil was abnormal, for the seed planted in it either failed to germinate or the young plants died rapidly. On the other hand, older plants transplanted from adjoining portions of the garden survived and made more or less growth. However, even in this case the growth was scarcely satisfactory.

The abnormal condition of the soil was particularly characteristic of that portion of the garden from which the sample was taken, although the other portions were also designated as unproductive. The poor germination and stunted growth of the plants could scarcely be attributed to lack of plant-food, for the soil received in the preceding years heavy applications of horse and cow manure and also a generous dressing of lime. Within that time the humus content of the soil was increased by at least one crop of rye and one crop of clover plowed under in the spring.

The facts in the case led to the belief that the interference with normal development could either be ascribed to lack of available phosphoric acid, and possibly also of available potash; or to the presence in the soil of bacteria or fungi which may injuriously affect the plants directly or indirectly. As to the lack of available phosphoric acid, it was quite evident that frequent applications of coarse, strawy manures, comparatively poor in this constituent, and likewise the heavy dressing of lime, might have created a deficiency. However, while a deficiency of available phosphoric

acid would readily account for the unsatisfactory growth of the crops after germination, it could scarcely explain the almost uniform failure of the seeds of various garden crops to germinate. On the contrary, poor germination is known to be due, frequently, to micro-organisms which attack the seed and cause its decay. Similarly, bacteria and fungi may destroy the roots of the young plants, or they may enter into competition with the latter, for the plant-food in the soil, and may create thereby conditions unfavorable for plant development.

From the bacteriological standpoint the problem presented by the Madison soil was one of considerable interest, and arrangements were made, therefore, to ascertain experimentally the probable source of the abnormal soil conditions. A section of the garden was divided into seven plots each 8 feet square, and separated from one another by narrow ditches. The different plots received the following treatment on August 31, 1906.

No. of plot.
1. Nothing.
2. 1.5 lbs. acid phosphate.
3. 0.75 " muriate of potash.
4. 1.00 " carbon bisulphide.
5. 1.00 " carbon bisulphide; 1.5 lbs. acid phosphate.
6. 1.00 " carbon bisulphide; 0.75 lbs. muriate of potash.
7. 2.00 " carbon bisulphide.

The acid phosphate and muriate of potash were applied broadcast, while the carbon bisulphide was poured into holes 10 inches deep, which were immediately filled with soil. The soil remained uncultivated until the following spring. On October 23d Mr. Seaman wrote: "Two or three days ago, I examined carefully the plots in the garden which you treated with various chemicals. As far as surface indications are concerned, I could not see any difference in the various plots. There were very few weeds in any of them, and it did not appear that the growth was any different in these various plots—that is they all appeared to have about the same quantity of weeds—which were very scant."

Towards the end of March, 1907, the several plots were seeded down to oats. The germination was good, but the growth was

materially affected by the dry weather, which prevailed throughout a portion of the growing season. A heavy rainstorm flattened out the crop when it was approaching maturity. Plots 1 and 2 alone escaped injury. The flattened grain was further damaged by the rabbits. "All together," wrote Mr. Seaman, "I feel that the result of the experiment is a failure as far as the amount of crop gathered, because the comparison between Nos. 1 and 2 and the remaining plots is very unfair." It should be added here that the lodging of the oats on plots 4, 5, 6 and 7 was hastened by the forcing effect of the carbon bisulphide which acts, in the year following its application, much like a heavy dressing of some nitrogenous fertilizer.

Aside from the soil tests at Madison, experiments were also carried out at the Station with soil shipped from Madison and used for both chemical and bacteriological studies. Twenty-pound quantities of the fresh soil were placed in large earthenware pots and after treatment analogous to that at Madison were seeded with millet and placed in the greenhouse. The fertilizer treatment was as follows:

No. of pot.		
1.	Nothing.	
2.	3 gms.	acid phosphate.
3.	2 "	muriate of potash.
4.	2 "	carbon bisulphide.
5.	2 "	carbon bisulphide; 3 gms. acid phosphate
6.	2 "	carbon bisulphide; 2 gms. muriate of potash
7.	4 "	carbon bisulphide.
8.	3 "	calcium carbonate.
9.	10 "	calcium carbonate.
10.	20 "	calcium carbonate.

It will be noted here that the greenhouse experiments contained 3 pots treated with various quantities of calcium carbonate. The latter was employed in order to determine whether the soil at Madison had not received in preceding years too large an application of magnesian lime. According to Loew, disturbances in plant-growth may be caused by an improper lime-magnesia ratio; and it seemed possible, therefore, that the Madison soil contained an excess of magnesia, a condition which was to be

corrected by the application of calcium carbonate in the greenhouse experiment.

The germination of the millet was good in all of the pots. As the growth proceeded considerable differences appeared in the size and color of the plants. The pots which were treated with carbon bisulphide or with carbon bisulphide and acid phosphate, not only bore a larger crop, but their plants were of a deeper green, an indication that the carbon bisulphide had encouraged the decomposition of the organic matter in the soil by bacteria and had thus provided a larger supply of available nitrogen compounds in the soil. The millet was harvested toward the end of March, dried and weighed. The amounts of air-dry matter secured were as follows:

Pot No.		Pot No.	
1.	18 gms.	6.	14 gms.
2.	20 "	7.	23 "
3.	19 "	8.	20 "
4.	30 "	9.	21 "
5.	40 "	10.	20 "

The returns indicate that muriate of potash was of no advantage to the crop. When used alone it led to a very slight increase over the untreated soil, while in combination with carbon bisulphide it led to a decided decrease. Acid phosphate when used alone led to an increase from 18 to 20 gms. of dry matter. When used in combination with carbon bisulphide the increase was still greater, since the increase due to carbon bisulphide alone was 30 gms. less 18 gms., or 12 gms., whereas the increase from the combined treatment was 40 gms. less 18 gms., or 22 gms. In pot 7, where the double quantity of carbon bisulphide was used the increase in yield was smaller than that in pot 4, where the single quantity was used, an indication that the larger application had injured the soil bacteria to a greater extent than did the smaller application, and that the recovery from this injury was not as rapid in the former.

The application of calcium carbonate led to a small increase in the yield of dry matter. The larger applications were, how-

ever, scarcely more beneficial than the smaller applications, and it must be concluded, therefore, that whatever the cause of the abnormal conditions in the Madison soil, it was not due to an improper lime-magnesia ratio. Had this been the case, the larger application should have led to a greater increase than did the smaller application of calcium carbonate.

BACTERIOLOGICAL STUDIES.

After the removal of the millet, a sample was drawn from each of the ten soils with the usual precautions as to contamination. The samples were then removed to the laboratory and used for the inoculation of the corresponding culture solutions for the measure of the ammonifying, nitrifying and denitrifying, and nitrogen-fixing power of the several soils.[1] One hundred cubic centimeters of the culture solution were inoculated in each case with ten grams of soil, and kept in the incubator at 28° C.

THE AMMONIFYING POWER OF THE SOILS.

The 20 portions of the 1% solution of gelatin used here were inoculated on April 1. Ten of the cultures were analyzed for ammonia on April 4th, and the remainder on the following day. The following amounts of ammonia-nitrogen were found:

Soil.	April 4.	April 5.	Average.
1,	7.18 mg.	18.17 mg.	12.67 mg.
2,	10.47 "	24.67 "	17.57 "
3,	7.53 "	17.31 "	12.42 "
4,	9.26 "	27.26 "	18.26 "
5,	12.55 "	21.90 "	17.22 "
6,	11.94 "	25.79 "	18.86 "
7,	9.78 "	20.25 "	15.01 "
8,	10.39 "	23.80 "	17.09 "
9,	11.34 "	24.67 "	19.00 "
10,	13.07 "	26.57 "	19.82 "

[1]See N. J. Station Report, 1905, p. 223; 1906, p. 117.

The quantities of ammonia produced in the gelatin cultures of the different soils show some instructive variations. At the end of 3 days the soils which had received an application of acid phosphate produced an increased amount of ammonia as against the untreated soil No. 1. Moreover, soil No. 5, which had received an application of carbon bisulphide besides that of acid phosphate, led to the production of more ammonia than did soil No. 2, which had received acid phosphate only. Soil No. 4, which received an application of carbon bisulphide also, possessed a higher ammonifying power than did soil No. 1. On the other hand, the application of muriate of potash led practically to no increase in the ammonifying power of the soil. When used together with carbon bisulphide, muriate of potash led to increased ammonification. The double quantity of carbon bisulphide was but slightly more effective than the single quantity in increasing the ammonifying power of the soil. The addition of lime, also caused a more intense ammonification, the increase being progressive from soil No. 8 to soil No. 10. In the case of the latter, the amount of ammonia produced in the three days old culture was actually greater than that produced in any of the others. Similar relations prevailed in the four days old cultures. All of the treated soils, with the exception of soil No. 3, where muriate of potash was used, showed an increased ammonifying power. The highest yield of ammonia-nitrogen was secured here in culture No. 4, where the single quantity of carbon bisulphide was used. The double quantity of carbon bisulphide was, on the other hand, by no means as effective in enhancing ammonification. The combination of acid phosphate and carbon bisulphide did not lead to the production of proportionately as much ammonia as it did in the three days old culture. The application of lime resulted in a progressively increased ammonification as it did in the three days old cultures. It seems thus that the acid phosphate, carbon bisulphide and lime stimulated the growth of the ammonifying bacteria. In comparing, however, the yields of millet secured from the several soils, we find that the markedly increased ammonification in the limed soils did not lead to any considerable

increase in the yield of dry matter, whereas the carbon bisulphide when used alone or in combination with acid phosphate led to a very marked increase in the yields of dry matter. How are the discrepancies to be accounted for? Are they due to the direct stimulating action of the carbon bisulphide on plant growth, or are they due to its stimulating action on the various species of soil bacteria and its rendering available through their activities not only of greater quantities of nitrogen, but also of phosphoric acid and of other mineral food. It seems interesting to inquire also why the increased ammonification as due to greater quantities of lime was not followed by a corresponding increase in the yield of dry matter. There is reason to think, at any rate, that in the limed soils nitrogen was not a controlling factor of growth, and that the supply of available phosphoric acid, or some other condition determined the rate of plant development.

THE NITRIFYING POWER OF THE SOILS.

The nitrifying power of the different soils was determined by the inoculation of 100 cc. portions of the following solution:

1,000	cc.	tap-water.
2.0	gms.	ammonium sulphate.
1.0	"	potassium phosphate.
0.5	"	magnesium sulphate.
0.4	"	ferric sulphate.
2.0	"	sodium chloride.

Each 100 cc. portion of this solution received 1 gm. of magnesium carbonate, and after sterilization was inoculated with 10 gms. of soil. Two cultures were prepared from each soil. After standing in the incubator at 28° C. for twenty-five days the several cultures were analyzed for ammonia, nitrite and nitrate nitrogen, respectively. The amounts found were as follows:

Soil No.	Ammonia N.		Nitrite N.		Nitrate N.		Total.	
1 (a),..	10.35 mg.	Average.	11.68 mg.	Average.	0.161 mg.	Average.	22.19 mg.	Average.
1 (b),..	5.90 "	8.12 mg.	15.58 "	13.63 mg.	0.200 "	0.180 mg.	21.64 "	21.91 mg
2 (a),..	0.43 "		18.51 "		0.250 "		19.19 "	
2 (b),..	1.62 "	1.02 "	16.22 "	17.36 "	0.222 "	0.236 "	18.06 "	18.62 "
3 (a),..	0.51 "		27.18 "		0.167 "		27.86 "	
3 (b),..	0.51 "	0.51 "	27.05 "	27.11 "	0.400 "	0.283 "	27.96 "	27.91 "
4 (a),..	0.51 "		30.43 "		0.250 "		31.19 "	
4 (b),..	16.17 "	8.34 "	12.17 "	21.30 "	0.154 "	0.202 "	18.49 "	24.84 "
5 (a),..	12.75 "		14.31 "		0.175 "		27.23 "	
5 (b),..	11.89 "	12.32 "	17.81 "	16.06 "	0.154 "	0.164 "	28.85 "	28.04 "
6 (a),..	2.22 "		25.62 "		0.222 "		28.06 "	
6 (b),..	0.34 "	1.28 "	31.23 "	28.42 "	0.200 "	0.211 "	31.77 "	29.91 "
7 (a),..	0.94 "		25.62 "		0.143 "		26.70 "	
7 (b),..	0.34 "	0.64 "	29.50 "	27.56 "	1.000 "	0.571 "	30.84 "	28.77 "
8 (a),..	13.77 "		11.18 "		0.118 "		25.07 "	
8 (b),..	0.00 "	6.88 "	36.06 "	23.62 "	0.200 "	0.159 "	36.26 "	30.66 "
9 (a),..	15.91 "		8.55 "		0.182 "		24.64 "	
9 (b),..	5.05 "	10.48 "	22.50 "	15.52 "	0.332 "	0.257 "	27.88 "	26.26 "
10 (a),..	0.34 "		38.25 "		0.125 "		38.71 "	
10 (b),..	6.50 "	3.42 "	19.02 "	28.63 "	0.222 "	0.173 "	25.74 "	32.22 "

The data in the above table are irregular and inconclusive. In a number of instances, the duplicate inoculations show wide divergences. For instance, the duplicate cultures 4a and 4b contained 0.51 mg. and 16.17 mg., respectively, of ammonia-nitrogen; the duplicate cultures 8a and 8b contained 13.77 mg. and 0.00 mg., respectively; and the duplicate cultures 9a and 9b contained 15.91 mg. and 5.05 mg., respectively. It seems, thus, that the variations in the rate of transformation of ammonia into nitrite nitrogen were greater in the parallels than they were between different soils. Notwithstanding these discrepantices, however, it is worth while to note here that the acid phosphate when used alone encouraged the disappearance of the ammonia, while its use with carbon bisulphide did not lead to the same result. On the other hand, the muriate of potash encouraged the disappearance of the ammonia, either when used alone or in combination with carbon bisulphide. Similarly, the double quantity of carbon bisulphide was more effective than the single quantity in encouraging the disappearance of the ammonia. The influence of the different applications of lime, as reflected in the oxidation of the ammonia was not definite. There is an indication here, however, that the largest quantity of lime was at least fully as effective as the smaller applications in hastening the oxidation of ammonia.

The amount of nitrite nitrogen found in the cultures also show considerable variations in the duplicates. We find thus 8.55 mg.

of nitrite nitrogen in 9a and 22.50 mg. in 9b. Also in the case of the nitrites, however, the influence of the soil treatment is apparent to a greater or less extent. Soil No. 1, to which nothing had been applied, yielded the least amount of nitrite nitrogen. Again, the acid phosphate was by no means as effective as the muriate of potash in encouraging nitrification in the culture solutions. Soil No. 2, where acid phosphate was used alone, led to the formation of 17.36 mg. of nitrite nitrogen; and soil No. 5, where acid phosphate was used in combination with carbon bisulphide, led to the formation of 16.06 mg. of nitrite nitrogen. On the other hand, soils No. 3 and No. 6, where muriate of potash was used alone and in combination with carbon bisulphide, respectively, led to the production of comparatively large amounts of nitrite nitrogen. This result is somewhat instructive, for it will be remembered that muriate of potash alone apparently depressed the activities of the ammonifying bacteria. We have here, then, a differentiation between the influence of muriate of potash on ammonifying bacteria on the one hand, and of nitrifying bacteria on the other. The influence of lime on the formation of nitrites in the culture solutions is not brought out definitely. The medium application of lime to the soil led to the formation of the least quantity of nitrite nitrogen, while the largest application led to the formation of the largest quantity of nitrite nitrogen in the culture solutions.

The formation of nitrates had not proceeded very far in the 25 days of the experiment. The largest amount produced was 1.00 mg. in culture 7b, while in the duplicate inoculation only 0.143 mg. had been formed. The data in question seem to support the claim of Winogradsky and Omelianski that the transformation of nitrite nitrogen into nitrate nitrogen is delayed until most of the ammonia in the culture solution is used up. The ammonia acts here as a poison to the nitric ferments. It does not follow, however, that in the soil itself, or in culture solutions differently constituted the same facts would be observed; in other words, under different conditions comparatively large amounts of ammonia may not prove as injurious to the nitric ferments, and the transformation of nitrite into nitrate may then proceed more rapidly.

The sum of the ammonia, nitrite and nitrate nitrogen, as given in the last column of the table is considerably below the amount of ammonia nitrogen originally present in each culture solution; namely, about 40 mg. In the inoculations with soil No. 1 nearly one-half of this nitrogen disappeared; in the inoculations with soil No. 2 more than one-half of it was lost; while in the inoculations with the other soils the losses, if not as extensive, were quite large. They may be accounted for either by the volatilization of ammonia from the culture solutions, or its transformation into soluble organic compounds.

THE DENITRIFYING POWER OF THE SOILS.

The culture solution used here was made up as follows:

1,000 cc. distilled water.
2 gms. magnesium sulphate.
2 " potassium phosphate.
1 " potassium nitrate.
0.2 " calcium chloride.
5.0 " citric acid.
2 drops of a 10% solution of ferric chloride.

The solution containing these substances was neutralized, while boiling, with sodium hydrate, and 2 gms. of dextrose was then added. One hundred cubic centimeter portions of this solution were inoculated each with 10 gms. of soil, and placed in the incubator at 28° C. At the end of 10 days the several cultures were tested with diphenylamine for nitrates and were found to give negative results. They were then tested for total nitrogen according to the Kjeldahl method. The amounts of nitrogen found, as well as those originally present in the culture solution and in the soil used for inoculation, are given in the following table:

Soil No.	Nitrogen in Culture Solution and Soil.	Nitrogen Found.	Nitrogen Lost.	Average Loss.
1 (a), ...	32.81 mg.	23.99 mg.	8.82 mg.	
1 (b), ...	32.81 "	25.37 "	7.44 "	8.13 mg.
2 (a), ...	32.38 "	25.54 "	6.84 "	
2 (b), ...	32.38 "	25.37 "	7.01 "	6.92 "
3 (a), ...	32.99 "	24.85 "	8.14 "	
3 (b), ...	32.99 "	25.54 "	7.45 "	7.79 "
4 (a), ...	32.21 "	25.71 "	6.50 "	
4 (b), ...	32.21 "	24.42 "	7.79 "	7.14 "
5 (a), ...	32.47 "	24.68 "	7.79 "	
5 (b), ...	32.47 "	25.37 "	7.10 "	7.44 "
6 (a), ...	32.50 "	26.40 "	6.10 "	
6 (b), ...	32.50 "	26.49 "	6.01 "	6.05 "
7 (a), ...	31.52 "	25.98 "	5.54 "	
7 (b), ...	31.52 "	27.27 "	4.25 "	4.89 "
8 (a), ...	32.55 "	27.27 "	5.28 "	
8 (b), ...	32.55 "	26.75 "	5.80 "	5.39 "
9 (a), ...	31.03 "	25.11 "	5.92 "	
9 (b), ...	31.03 "	25.54 "	5.49 "	5.70 "
10 (a), ...	32.07 "	25.54 "	6.53 "	
10 (b), ...	32.07 "	25.03 "	7.04 "	6.78 "

The soil treatment had evidently reduced the denitrifying power of the soils, as indicated by the above tabulation. The acid phosphate in soil No. 2 depressed the activities of the denitrifying bacteria to a greater extent than did the muriate of potash in soil No. 3, and the single quantity of carbon bisulphide in soil No. 4. When, however, the acid phosphate was used in combination with carbon bisulphide it was not as effective in reducing denitrification as was the muriate of potash when used in combination. The double quantity of carbon bisulphide inhibited the activities of the denitrifying bacteria to a much greater extent than did any of the other treatments employed. It is interesting to note in this connection that the double quantity of carbon bisulphide was not as effective as the single quantity in enhancing the ammonifying power of the soil. It seems thus that both the ammonifying and the denitrifying bacteria were depressed in their development by the larger amount of carbon bisulphide. On the other hand, the nitrifying bacteria were not apparently affected to the same extent by larger applications of carbon bisulphide, as was already noted in a preceding table.

It appears, likewise, from the above tabulation that the denitrifying power of the soil was affected by the lime treatment. Soil No. 8, which had received the smallest application of lime, led to an average loss of 5.39 mg. of nitrogen from the culture solutions; soil No. 9, which had received the medium application of lime, led to a loss of 5.70 mg. of nitrogen; and soil No. 10, which had received the large application of lime, led to a loss of 6.78 mg. of nitrogen. These results are not without a certain amount of interest as bearing on the question of gain and loss of nitrogen in the soil. It is well to remember in this connection that the ammonifying power of the three soils in question showed an increase over that of the untreated soil. On the contrary, the denitrifying power of the limed soils showed an increase over that of the untreated soil, an indication that the denitrifying bacteria proper are not affected to the same relative extent by lime treatment as is the entire group of ammonifying bacteria. It should be again noted here, however, that with the increasing quantities of lime applied to the soil the depression in the activities of the denitrifying bacteria became less prominent, a fact which may lead to the suggestion that while moderate dressings of lime may depress denitrification in the soil, heavy dressings of lime may increase it under certain conditions. The repeated observation that soils which had been heavily limed contain less nitrogen than similar unlimed soils may be accounted for not only by the more intense nitrification processes in the limed soils and the removal of the nitrates in the crops and in the drainage waters, but perhaps also by the decomposition of some of the nitrate by bacteria.

THE NITROGEN-FIXING POWER OF THE SOILS.

The culture solution employed here had the following composition:

1,000 cc. tap-water.
15 gms. mannite.
0.5 " potassium phosphate.
0.2 " magnesium sulphate.
0.02 " calcium chloride.
1 drop 10% solution of ferric sulphate.

The culture solution was then made slightly alkaline to phenolphthalein with sodium hydrate, portioned off in 100 cc. quantities in flat-bottomed 500 cc. Jena flasks, sterilized, cooled, and inoculated in each case with 10 gms. of soil. The cultures were kept in the incubator at 28° C. for 10 days, at the end of which time they were analysed for total nitrogen according to the Kjeldahl method. All of the cultures developed characteristic Azotobacter membranes. Plates prepared from these growths allowed the ready isolation of at least two Azotobacter species, A. Beyerincki and A. chroococcum. There was no doubt, therefore, that the Madison soils possessed a pronounced nitrogen-fixing power, due largely to a vigorous Azotobacter flora. The prominence of the latter was undoubtedly made possible by the generous amounts of lime and of coarse manure which had been applied to the soil. The following table shows the amount of nitrogen present in each case in the soil and culture solution at the beginning of the experiment, as well as that present at the end of the experiment. The differences represent the gain due to the fixation of atmospheric nitrogen by bacteria.

Soil No.	Nitrogen in Cultures at the End of the Experiment.	Nitrogen in Cultures at the Beginning of the Experiment.	Gain.	Average Gain.
1 (a), ...	31.41 mg.	18.95 mg.	12.46 mg.	
1 (b), ...	31.67 "	18.95 "	12.72 "	12.59 mg.
2 (a), ...	30.38 "	18.52 "	11.86 "	
2 (b), ...	30.55 "	18.52 "	12.03 "	11.94 "
3 (a), ...	31.41 "	19.13 "	12.28 "	
3 (b), ...	31.06 "	19.13 "	11.93 "	12.10 "
4 (a), ...	31.24 "	18.35 "	12.89 "	
4 (b), ...	31.11 "	18.35 "	12.76 "	12.82 "
5 (a), ...	30.98 "	18.61 "	12.37 "	
5 (b), ...	29.17 "	18.61 "	10.56 "	11.47 "
6 (a), ...	32.62 "	18.64 "	13.98 "	
6 (b), ...	34.35 "	18.64 "	15.71 "	14.84 "
7 (a), ...	33.91 "	17.66 "	16.25 "	
7 (b), ...	32.79 "	17.66 "	15.13 "	15.69 "
8 (a), ...	33.74 "	18.69 "	15.05 "	
8 (b), ...	33.22 "	18.69 "	14.53 "	14.79 "
9 (a), ...	33.05 "	17.17 "	15.88 "	
9 (b), ...	Lost	17.17 "	.....	.....
10 (a), ...	33.31 "	18.21 "	15.10 "	
10 (b), ...	33.74 "	18.21 "	15.53 "	15.31 "

The fixation of atmospheric nitrogen in the culture solutions inoculated with Madison soil was in all cases quite considerable. In the inoculations with soils 6, 7, 8, 9 and 10 the yields of combined nitrogen were, on the average, at the rate of more than 15 mg. per 1.5 gms, of mannite, or at the rate of more than 10 mg. per 1 gm. of mannite. That the nitrogen-fixing bacteria were influenced by the previous treatment of the soil is evidenced by the larger yields in some of the cultures. Thus, the inoculations from soils 8, 9 and 10 which had received applications of lime led to a considerable increase over those from soil No. 1 which had received nothing. One of the cultures from soil No. 9 was lost in the digestion on the furnace, none the less, it seems that the fixation of nitrogen was encouraged by the larger applications of lime. The acid phosphate and muriate of potash when used alone led to decreased nitrogen-fixation by the soil. The single quantity of carbon bisulphide was not detrimental to the nitrogen-fixing bacteria, and there is an indication that it was, perhaps, slightly beneficial. Where used in combination with the single quantity of carbon bisulphide the acid phosphate again proved detrimental to the nitrogen-fixing bacteria. On the other hand, the muriate of potash when similarly used in combination with carbon bisulphide led to a very marked increase in the activities of the nitrogen-fixing bacteria. The double quantity of carbon bisulphide proved superior to any of the other treatments, as a means for encouraging the activities of the Azotobacter and of other nitrogen-fixing species. This is quite in accord with the observations of Heinze[1] on the stimulating action of moderate amounts of carbon bisulphide on the growth of Azotobacter.

We see thus that the double application of carbon bisulphide showed, two months later, the following effect on the soil:

(1) Ammonification had evidently been retarded at first, but subsequently became more intense, not sufficiently so, however, to equal the effect of the other treatments. (2) Nitrification was more intense than in the untreated soil. (3) Denitrification was much less prominent than in the untreated soil. (4) Nitro-

[1]Centrbl. Bakt., etc., II, vol. XVI, p. 329.

gen-fixation was markedly superior to that in the untreated soil.

The treatment with acid phosphate led to a comparatively large increase in ammonification; a comparatively small increase in nitrification; a decrease in denitrification, and a decrease in nitrogen fixation.

The treatment with acid phosphate and single quantity of carbon bisulphide led to a marked increase in ammonification; an increase in nitrification; a small decrease in denitrification; a decrease in nitrogen fixation.

Muriate of potash led to a decrease in ammonification; increase in nitrification; slight decrease in denitrification; slight decrease in nitrogen fixation.

When used in combination with the single quantity of carbon bisulphide, muriate of potash led to an increase in ammonification; increase in nitrification; decrease in denitrification; increase in nitrogen fixation.

The lime treatment led to a pronounced gain in ammonification; a gain in nitrification; a decrease in denitrification; and an increase in nitrogen fixation.

A comparison of the effects of carbon bisulphide, single and double quantity, and of acid phosphate together with the single quantity of carbon bisulphide, on the crop yields and the bacteriological activities shows the following:

Soil Treatment.	Dry Matter in Crop.	Gain over Untreated.	Ammonification.	Gain over Untreated.	Nitrification.
Nothing, ...	18 gms.	....	12.67 mg.	....	13.63 mg.
Carbon bisulphide (single quantity), ...	30 "	12 gms.	18.26 "	5.59 mg.	21.30 "
Carbon bisulphide and acid phosphate, ...	40 "	22 "	17.22 "	4.55 "	16.06 "
Carbon bisulphide (double quantity), ...	23 "	5 "	15.05 "	2.38 "	27.56 "

Soil Treatment.	Gain over Untreated.	Denitrification.	Loss over Untreated.	Nitrogen Fixation.	Gain over Untreated.
Nothing, ...	....	8.13 mg.	....	12.59 mg.	....
Carbon bisulphide (single quantity), ...	7.67 mg.	7.14 "	0.99 mg.	12.82 "	0.23 mg.
Carbon bisulphide and acid phosphate, ...	2.43 "	7.44 "	0.69 "	11.47 "	1.12 " loss
Carbon bisulphide (double quantity), ...	13.93 "	4.89 "	3.24 "	15.69 "	3.10 "

The crop yields were markedly increased by the single quantity of carbon bisulphide, and still more so when acid phosphate was used together with the latter. Now, moderate amounts of carbon bisulphides by increasing the activities of the ammonifying, nitrifying and nitrogen-fixing bacteria, and decreasing the activities of the denitrifying bacteria provide for a more abundant supply of available nitrogen compounds to the crop. Under such conditions, the phosphoric acid is allowed to be utilized more extensively, as was actually the case in the present experiment. The more vigorous growth of the crop in the soil treated with carbon bisulphide and acid phosphate was not accompanied, however, by a corresponding encouragement to the growth of the ammonifying, nitrifying and nitrogen-fixing bacteria, as may be seen by comparing the data in the above table. Carbon bisulphides alone led to a gain in ammonification of 5.59 mg. as against 4.55 mg. for the combination of carbon bisulphide and acid phosphate. The corresponding figures for nitrification were 7.67 mg. and 2.43 mg., respectively; and for nitrogen-fixation +0.23 mg. and —1.12 mg. respectively. It is uncertain why the larger crop growth should have been followed by a marked depression in the activities of the three groups of bacteria. It is possible, however, that the vigorous plant growth and the withdrawal of available plant-food, and perhaps also the diffusion from the plant roots into the soil of certain organic substances, were responsible for the conditions observed. It does not follow, at the same time, that the depression in the bacterial activities extended throughout the growing period of two months. On the contrary, it is more likely that this depression became apparent only after the plants had attained a considerable development.

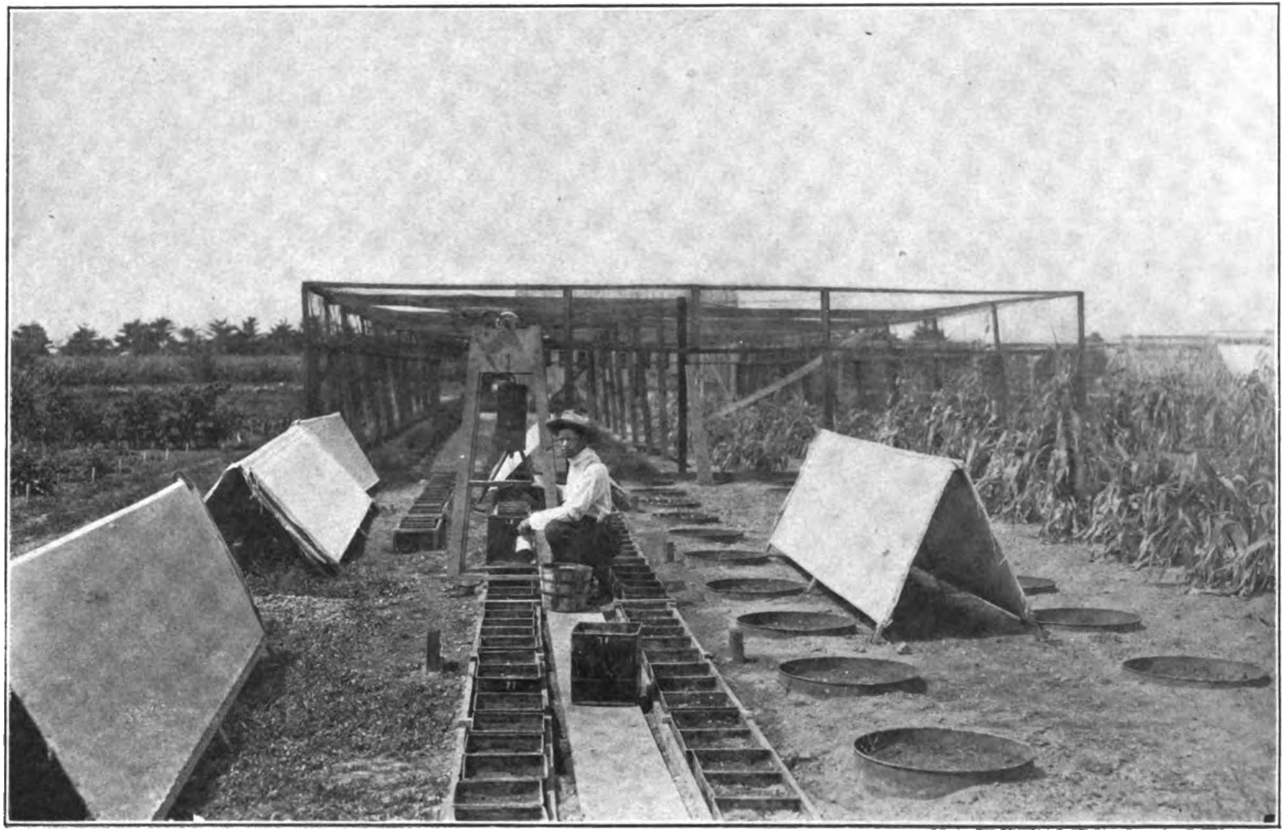
Finally, it may be worth while to note here that the double quantity of carbon bisulphide, as compared with the single quantity, affected the different groups of bacteria unequally. The crop yields showed a gain of 12 gms. of dry matter for the single quantity, and of 5 gms. for the double quantity. Similarly in the bacteriological relations the single quantity of carbon bisulphide showed a gain of 5.59 mg. and the double quantity of 2.38 mg. in ammonification. The amount of nitrite formed, on the other hand, was 7.67 mg. for the single quantity, and

13.93 mg. for the double quantity. The corresponding amounts for the nitrogen fixed were 0.23 mg. and 3.10 mg., respectively. The decreased loss from denitrification was 0.99 mg. for the single quantity, and 3.24 mg. for the double quantity. This shows that in the space of two months the ammonifying bacteria had not yet recovered from the injurious effect of the larger quantity of carbon bisulphide. The same may be said of the denitrifying bacteria. On the other hand, the nitrous ferments and the nitrogen-fixing Azotobacter had become in the same length of time more active, thanks to this larger application. Accepting Hiltner and Störmers claim that in the normal soil flora the different groups occur in fairly definite relations, we find that these relations are evidently disturbed by applications of carbon bisulphide, as was already noted by these investigators. According to them the carbon bisulphide, by destroying the existing bacterial equilibrium prepares the way for an entirely new bacterial development, whereby certain species become far more prominent than they had been previously. This seems to apply, in the present experiment, to the nitrifying and nitrogen-fixing bacteria.

Ammonification in Culture Solutions as Affected by Soil Treatment.

Previous experiments[1] have indicated that the decomposition of peptone and of gelatin solutions by decay bacteria derived from the soil bears a certain analogy to the decomposition of the humus in the soil itself. A soil whose bacteria are more numerous and more vigorous than those of another soil will not only cause more intense decomposition in culture solutions, but will also cause a more rapid decay of the soil humus and the production of a greater quantity of available nitrogen compounds. But aside from the decay bacteria proper there are other groups of soil bacteria, and methods of tillage, fertilization, and crop rotation which favor the rapid development of one class of bacteria need not necessarily favor the rapid development of other classes of bacteria. It is desirable, therefore, to differ-

[1]See New Jersey Station Report 1906, page 119.



Box Experiments.

entiate as far as possible the activities of the various groups of soil organisms, and any methods that would permit such differentiation deserve a careful study.

The so-called ammonifying bacteria, which include a large part, if not all, of the saprophytic organisms, are quite susceptible to changes in the moisture content of the soil; in the concentration of the soil solution; in the amount and quality of the organic matter, and in the rate of diffusion of the soil gases. Such changes, apart from climatic conditions, are brought about by operations of tillage, by crop rotations, and by manure and fertilizer treatment. It is not known, however, what comparative value certain applications of fertilizers, or certain systems of rotation may have in enhancing or depressing ammonification in the soil. The experiments recorded in the following pages were planned, therefore, to test, on the one hand, the value of laboratory methods as a measure of ammonification, and on the other the influence exerted by various methods of soil treatment on the numbers and vigor of the decay bacteria in the soil.

The experiments were carried out in metal boxes painted both inside and out. Five pounds of clean pebbles were placed in each box, and on top of that 45 pounds of clay loam soil. Water was then added to the extent of 14%, and an attempt was made to keep this proportion of water in the soil as nearly constant as possible. The water was usually poured in a depression made for the purpose at one end of the box, and the surface of the soil was stirred from time to time. All of the boxes were placed in a trench deep enough to allow only about an inch of the upper portion of the box to project above ground. From time to time the boxes were taken out of the trench by means of a mechanical contrivance especially devised for the purpose, and the water was added by weight to restore the losses by evaporation.

Protection against heavy rainfall was secured by means of canvas covers, which were usually placed over the boxes in the evening and removed in the morning. No weeds were allowed to grow in any of the soils so that the nitrates or other nitrogen compounds were subject to decomposition or transformation by lower organisms alone. It seemed desirable in this connection to find out whether the accumulation of nitrates in bare soils has a

limit, it having been found in other experiments that after accumulating up to a certain point the nitrates in the soil disappear again gradually even where losses from leaching are excluded.

For the bacteriological work the soils in the boxes were sampled with the usual precautions against contamination. The samples were then taken to the laboratory and inoculated on the same day into sterile culture solutions. In the ammonification studies reported here 1% solutions of gelatin in tap water were used. After standing at room temperature for a few days the culture solutions were boiled with magnesia, the distillate was collected, and the ammonia in the latter determined in the usual way.

SERIES I.

Box No.	Treatment.	Ammonia Nitrogen Produced — In 3 Days. mgs.	In 5 Days. mgs.	Average. mgs.	Nitrate Nitrogen in Soil. pts. per million.
1.	Nothing, ...	9.84	24.76	17.30	21.73
2.	12 gms. $CaCO_3$, ...	11.81	38.38	25.09	5.55
3.	24 " "	16.73	46.08	31.40	9.43
4.	36 " "	14.27	52.64	33.45	15.50
5.	12 " $MgCO_3$, ...	23.62	61.34	42.48	8.33
6.	24 " "	18.20	59.86	39.03	12.34
7.	36 " "	14.43	47.89	31.16	19.80
8.	6 " $CaCO_3$, 6 gms. $MgCO_3$,	10.33	41.33	25.83	9.80
9.	12 " " 12 " "	12.30	40.02	26.16	6.25
10.	18 " " 18 " "	16.07	49.04	32.55	11.23

It will be observed that in Series I. an attempt was made to study the influence of varying quantities of calcium carbonate, of magnesium carbonate, and of mixtures of the two, on ammonification in gelatin solutions. The samples for inoculation were drawn two weeks from the beginning of the experiment, a period too short for the development of deep-seated changes in the bacterial soil-flora. None the less, it is shown by the results that in even this short period the several soils had undergone modification. Equivalent quantities of the originally identical soils caused the formation of rather different amounts of ammonia in the culture solution, according to the quantity of lime or magnesia applied. It is evident that the ammonifying power of the box soils was increased by the applications of lime. Thus at the end of three

days soil 1 produced 9.84 mg. of ammonia nitrogen in the gelatin solution, the smallest amount found in any of the cultures. Similarly, in the duplicate culture inoculated at the same time, but analysed two days later, the amount of ammonia nitrogen produced was 24.76 mg., the smallest found in the five days old cultures. With the increase in the amount of lime applied the amounts of ammonia showed a corresponding increase in most instances. In soil 2 the 12 gms. of calcium carbonate increased the ammonification coefficient from 9.84 mg. to 11.81 mg. Soil 3 showed a further increase to 16.73 mg. while soil 4 did not lead to a further increase. In the 5 days old cultures we find the increase to have been constant, namely, 24.76 mg. for soil 1, 38.38 mg. for soil 2, 46.08 mg. for soil 3, and 52.64 mg. for soil 4. The average for the 3 and 5 days old cultures show the same consistent increase for the four soils.

The application of magnesium carbonate had evidently affected the ammonifying power of the soil in a somewhat different manner. In soil 5 which had received 12 gms. of magnesium carbonate the ammonification coefficient was 23.62 mg. at the end of three days, and 61.34 mg. at the end of four days, the largest secured in the experiment. On the other hand the large applications of magnesium carbonate exerted a depressing effect as measured against that of the 12 gms. application. The results secured with the three days old cultures and with the parallel 5 days old cultures are quite consistent. The average for the two sets shows an ammonification coefficient of 42.48 mg. for soil 5; 39.03 mg. for soil 6; and 31.16 mg. for soil 7. It should be noted here that the cultures inoculated with soil 7 contained at the end of 3 days, and even more so at the end of 5 days, greater amounts of ammonia nitrogen than were found in the cultures from soil 1. In other words, we must assume that the 36 gms. of magnesium carbonate stimulated the activities of some of the soil bacteria while it depressed the activities of other species, and that the algebraic sum of the various modifications led to a higher ammonification coefficient than that in the untreated soil.

Where the calcium and magnesium carbonates were used in combination the results were quantitatively similar to those ob-

tained in soils 2, 3 and 4. A slight difference is observed here, however, in that the ammonification coefficient of soil 9 showed a relatively small increase at the end of three days, and a small decrease at the end of 5 days, when compared with soil 8. Interesting differences are thus shown in the effect of lime treatment from the standpoint of the quantity and quality of the lime. An application of 1000 lbs. of lime per acre has not the same effect on the ammonification processes in the soil as an application of 2000 lbs. of lime. Moreover, non-magnesian lime may exert a somewhat different effect than magnesian lime depending upon the character of the soil and the treatment to which it is subjected. To be sure, ammonification is but a single phase in the cycle of transformation which the nitrogen in the soil undergoes; it is none the less an essential phase. The organic nitrogen compounds in the humus must undergo a more or less far-reaching change, and must reach the ammonia stage before they are in a fair way to be utilized by the crop. Now, the rate at which ammonia is formed during the growing season is variable from day to day, and it is quite clear that in many soils where nitrogen is the controlling factor of growth the rate of ammonification really determines the progress of the crop.

The present experiment brings out the fact that dressings of magnesian and of non-magnesian lime enhance the ammonification coefficient of the soil. It also shows that moderate dressings of magnesium carbonate may increase the ammonifying power of the soil, but that beyond a certain point larger quantities lead to a decrease. This helps to explain why in soils deficient in available nitrogen compounds the application of lime leads to an increase of crop for a season, or for several seasons, and that beyond this the soil fails to respond to liming unless applications of manure or of other nitrogenous organic materials are made. The more intense activities of the ammonifying bacteria hasten the decomposition of the humus until a point is finally reached when the quantity and quality of the humus is no longer suitable for their rapid and vigorous growth. Again, the soil may fail to respond to liming even though the activities of the ammonifying bacteria are still enhanced thereby. This may occur particularly when the soil is

more or less deficient in available phosphoric acid. Under such conditions the increased amounts of lime may further cut down the supply of available phosphoric acid, and may lead thereby to a decrease rather than an increase of crop. Ammonification experiments could probably be made to throw some light on this question, and could thus be employed as a means for forecasting the probable effect of lime in any particular soil.

The last column in the table shows the amounts of nitrate nitrogen, in parts per million, found in the box soil at the time the samples were drawn. It will be observed that in the untreated soil 1, there were 21.73 parts per million of nitrate nitrogen; the largest amount found in any of the soils. In soil 2, there were 5.55 parts per million; in soils 3, 9.43 parts; and in soil 4, 15.50 parts. Evidently, therefore, the addition of calcium carbonate retarded, at first, the formation of nitrates in the soil, but with the increasing quantities the conditions for nitrification were made more and more favorable. We note similar effects from the additions of magnesium carbonate. There were found in soil 5, 8.33 parts per million of nitrate nitrogen; in soil 6, 12.34 parts; and in soil 7, 19.80 parts. On the whole the magnesium carbonate promoted nitrification to a greater extent than did the calcium carbonate. When the calcium and magnesium carbonates were used together the formation of nitrate nitrogen was at first favored, since in soil 8 there were found 9.80 parts per million as against 5.55 parts in soil 2, and 8.33 parts in soil 5. In soil 9, on the other hand, where 12 gms. each of calcium and magnesium carbonate was applied there were only 6.25 parts per million of nitrate nitrogen, a reduction coincident with the diminished ammonification as already noted. In soil 10, with an application of 18 gms. each of calcium and of magnesium carbonate, there were found 11.23 parts per million; amounts smaller than those found in soil 4, and in soil 7. It seems, thus, that a mixture of equal amounts of calcium and magnesium carbonate was less efficient in promoting nitrification than was an equivalent quantity of either carbonate when used alone. This fast, if substantiated by further experimental evidence, is not without considerable interest. The evidence supplied by the culture solutions for ammonification, and the

evidence supplied by the soil itself for nitrification both agree in that they show the mixed carbonates to be inferior to the carbonates used alone. It may be pointed out here that the rate of nitrification in the soil is conditioned largely upon the rate of ammonification. The nitrifying bacteria are dependent for their raw material on the ammonifying bacteria. Hence, conditions unfavorable to the latter are in a measure also unfavorable for the former. This should not be construed to mean, of course, that conditions favorable for the ammonifying bacteria are necessarily also favorable for the nitrifying bacteria. Now and then conditions occur in the soil that practically inhibit the change of ammonia into nitrate without retarding to any marked degree the breaking down of the protein compounds in the humus. In like manner conditions may occur favoring the rapid formation of nitrates without stimulating to the same extent the activities of the ammonifying bacteria. The data in series I. may be taken as an illustration of the facts under discussion. It will be observed that in soils 5, 6, and 7 the larger applications of magnesium carbonate were followed by a corresponding increase in the amounts of nitrate nitrogen formed. In the case of ammonia formation, on the contrary, the amounts decreased with the increasing applications of magnesium carbonate. Here, then, is a seemingly unusual instance of decreasing ammonification and increasing nitrification. It is quite likely, however, that such instances are not at all rare under field conditions.

SERIES II.

Box No.	Treatment.	Ammonia Nitrogen Produced — In 3 Days. mgs.	In 3 Days. mgs.	Average. mgs.	Nitrate Nitrogen in Soil. pts. per million.
1.	Nothing,	20.45	23.92	22.18	21.11
2.	2.5 gms. acid phosphate,	Lost.	27.55	27.55	17.16
3.	5.0 " " "	24.74	23.59	24.16	17.42
4.	10.0 " " "	24.58	25.90	25.24	11.11
5.	2.5 " Thomas slag,	27.38	26.56	26.97	16.90
6.	5.0 " " "	30.02	28.77	29.39	10.55
7.	10.0 " " "	32.23	35.69	33.96	21.11
8.	2.5 " Bone Meal,	23.75	25.57	24.66	13.79
9.	5.0 " " "	20.12	23.26	21.69	14.83
10.	10.0 " " "	25.24	27.71	26.47	43.95

Series II. was arranged to show the effect of various phosphatic substances, applied in different amounts, on the ammonifying power of the soil. As in series I., or in all of the following series the metal boxes contained five pounds of clean pebbles and forty-five pounds of clay loam soil. The latter was maintained at fourteen per cent. of moisture.

The inoculation into the gelatin solutions was performed in duplicate, and the ammonia determinations were made in all of the cultures at the end of three days. A comparison of the amounts of ammonia nitrogen found shows that the acid phosphate had a tendency to increase somewhat the ammonifying power of the soil. This increase was slight, however, and quite irregular. The application of 2.5 gms. of acid phosphate increased the ammonification coefficient from 22.18 to 27.55 mgs. The application of 5.0 gms. of acid phosphate failed to produce a further increase; and the same may be said of the 10 gms. application. In the case of the Thomas slag, on the other hand, the increasing amounts applied did result in an increasing production of ammonia in the culture solutions. With an application of 5.0 gms. it was 29.39 mg., and with an application of 10.0 gms., 33.96 mg. This characteristic increase in the ammonification coefficient can hardly be ascribed, however, to the phosphoric acid in the slag. It was due rather to the large proportion of lime contained in it and to a slight extent, perhaps, also to the iron. The bone meal, like the acid phosphate, failed to yield any positive evidence to the effect that the ammonification bacteria in the soil had been markedly affected by the treatment. It may be that after a longer interval the influence of the phosphoric acid on the ammonification processes in the soil as well as in the culture solutions inoculated with the treated soil would become more evident. It should be remembered that we are dealing here with numbers, as well as with species relationships of soil bacteria, and that change in the numbers may be brought about more readily than change in species relationships. Changes of the latter sort are more gradual and need not necessarily find expression in changed ammonification coefficients. In other words, nitrifying, and nitrogen-fixing bacteria may become more promi-

nent, certain species of ammonifying bacteria suppressed and others brought to the fore without any marked increase or decrease in the amounts of ammonia nitrogen produced by equivalent quantities of soil in gelatin or peptone solutions. The advantages and defects of the present method for the study of the ammonification coefficients of soil lie, therefore, in the fact that while it allows a certain differentiation in the bacteriological processes of the soil, it does not permit this differentiation to be carried too far.

Turning now to the amounts of nitrates found in the soils of this series at the time of sampling we find the following:

In the untreated soil 1, there were found 21.11 parts per million of nitrate nitrogen.

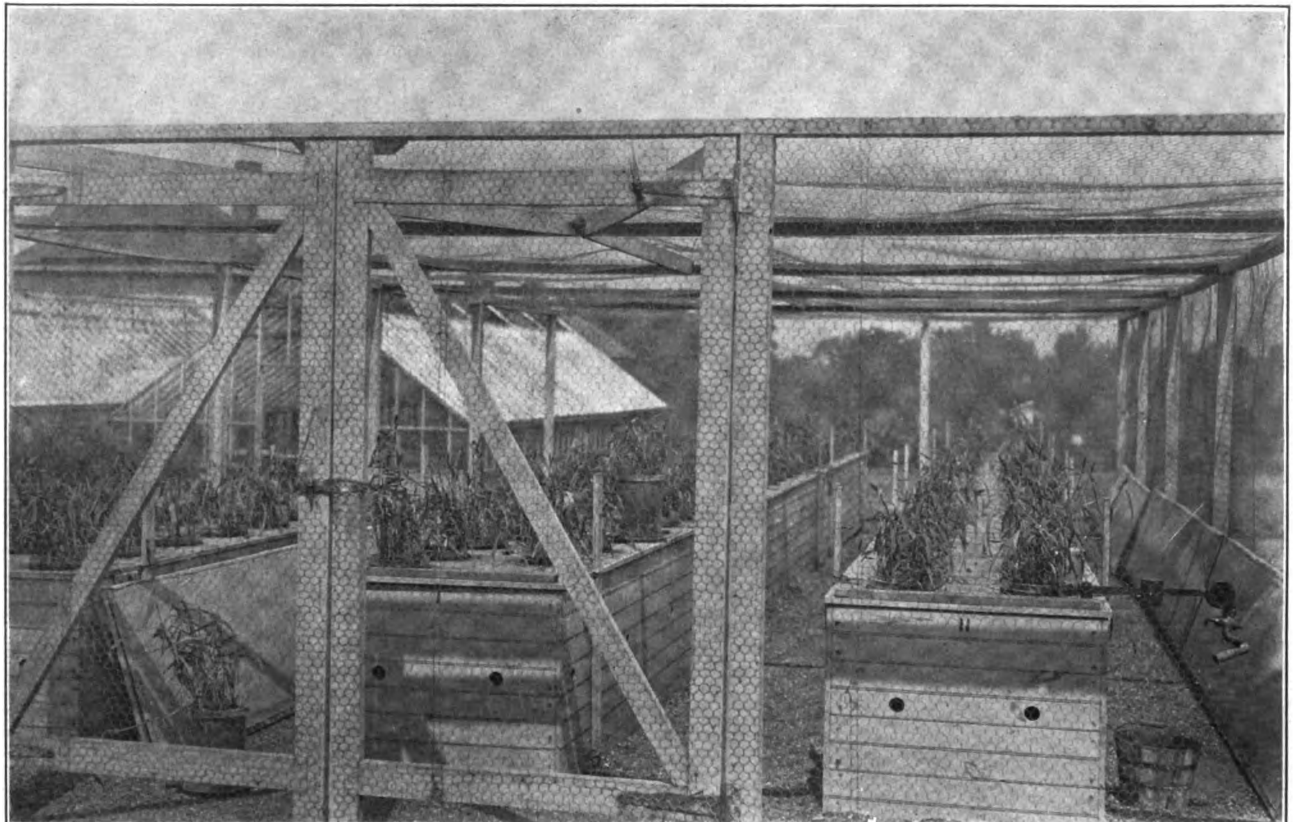
In soil 2, where 2.5 gms. of acid phosphate was applied the amount of nitrate nitrogen was less, only 17.16 parts per million.

Practically the same amount was found in soil 3 where 5.0 gms. of acid phosphate was applied.

In soil 4, which had received an application of 10.0 gms. of acid phosphate, the amount of nitrate nitrogen found was only 11:11 parts per million.

Similarly, the application of 2.5 gms. and of 5.0 gms. of acid phosphate modified the nitrification processes so that only 16.90 parts per million and 10.55 parts per million, respectively, of nitrate nitrogen were found in the soil. With an application of 10.0 gms. of Thomas slag nitrification, if not favored, was at least not retarded, since soil 7 contained at the time of sampling 21.11 parts per million of nitrate nitrogen.

In soils, 8, 9 and 10 the influence on nitrification of the bone meal applied was more marked than the influence of the acid phosphate and the Thomas slag in the corresponding soils. This applies, at any rate, to soil 10, where the largest quantity of bone meal was applied. The result here should probably be ascribed to the nitrogen supplied in the bone meal; nitrogen which was evidently readily nitrifiable to some extent at least. In soils 7 and 8, on the other hand, the amounts of nitrate nitrogen produced were still smaller than those in the untreated soil 1. It appears thus that a considerable difference exists between the nitrogen of the soil humus, and that supplied in manures and ferti-



Pot Experiments.

lizers, as to the readiness with which it will undergo nitrification. It may be noted here, likewise, that the amounts of nitrate nitrogen found in the soils under consideration may not represent all of the nitrogen oxidized by the bacteria. It may be safely assumed that a portion of the nitrogen nitrified is again changed into organic combinations by soil bacteria. To what extent such transformation affected the results in the present series cannot even be guessed.

SERIES III.

Box No.	Treatment.	Ammonia Nitrogen in the Culture Solutions		Average.	Ammonia Nitrogen in 25 gms. of Soil.	Nitrite Nitrogen in Soil.	Nitrate Nitrogen in Soil. Parts per million.
1.	Nothing,	29.19 mg.	36.09 mg.	32.64 mg.	....	0.175	57.1
2.	1.25 gms. Na NO_3,	28.07 "	29.99 "	29.03 "	0.32 mg.	0.238	53.6
3.	2.50 " "	35.77 "	31.44 "	33.60 "	0.32 "	0.188	100.0
4.	5.00 " "	45.23 "	37.53 "	41.38 "	0.32 "	0.232	108.2
5.	1.00 " $(NH_4)_2SO_4$,	28.71 "	32.08 "	30.39 "	0.32 "	0.176	62.5
6.	2.00 " "	25.98 "	25.18 "	25.58 "	0.22 "	0.146	61.0
7.	4.00 " "	25.82 "	28.23 "	27.02 "	0.32 "	0.271	63.5
8.	1.85 " Dried blood,	30.32 "	31.44 "	30.88 "	0.32 "	0.232	28.2
9.	3.70 " "	32.40 "	42.35 "	37.37 "	0.32 "	0.211	53.6
10.	7.40 " "	37.85 "	40.26 "	44.05 "	0.32 "	0.188	98.7
11.	2.00 " Calcium cyanamide,	31.92 "	38.82 "	35.37 "	0.32 "	0.229	27.8
12.	4.00 " " "	47.00 "	48.28 "	47.64 "	0.64 "	0.264	29.4
13.	8.00 " " "	36.73 "	43.31 "	40.02 "	0.64 "	0.292	27.4
14.	6.10 " Cyanate,	28.39 "	28.23 "	28.31 "	0.32 "	0.238	19.8
15.	12.20 " "	23.42 "	23.74 "	23.58 "	0.32 "	0.214	21.1
16.	24.40 " "	18.29 "	Lost.	18.29 "	1.66 "	0.268	21.0

Series III., as shown in the above table, was arranged for the study of ammonification as affected by the application to the soil of various nitrogenous substances. The materials employed included sodium nitrate, ammonium sulphate, dried blood, calcium cyanamide, and cyanate. The last named is a by-product in the manufacture of illuminating gas, and does not contain as much nitrogen as is contained in any of the other materials. The amounts of the several substances applied represented nitrogen equivalents. It will be observed that on account of the different proportion of nitrogen in these substances the amount of material used were at times quite considerable. For instance, in the case of the cyanate, the application of 24.40 gms. became necessary in order to secure the equivalent amount of nitrogen contained in 5.00 gms. of sodium nitrate. The several nitrogenous materials

were thoroughly incorporated with the soil in each case. The soils were then moistened, and maintained at a water content of 14 per cent. Six weeks later samples were drawn from these soils in the usual manner, removed to the laboratory, and inoculated on the same day in duplicate into sterile gelatin solutions. Determinations were made in the fresh samples of nitrite and nitrate nitrogen, and also of ammonia. For the determination of nitrites and nitrates 100 gms. of fresh soil were shaken for several minutes with 200 cc. of distilled water and 2 to 3 gms. of air slaked lime. The soil infusion thus produced, filtered quite clear and colorless, and was well suited for the colorimetric work. The ammonia in the soil was determined by the addition to 25 gms. of fresh material of an excess of magnesium oxide, and the volumetric measurement of the ammonia distilled over. In most of the soils the amount of ammonia nitrogen found was equivalent to 0.10 cc. of standard ammonium hydroxide solution, or 0.32 mg. of nitrogen. In three instances, however, the amounts of ammonia found in the fresh soil were more considerable. Thus in soils 12 and 13 where 4.00 gms. and 8.00 gms., respectively, of calcium cyanamide were applied the amount of ammonia present in each case was 0.64 mg. A still larger amount of ammonia nitrogen was found in soil 16 where 24.40 gms. of cyanate had been applied. The relatively large amounts of ammonia nitrogen in the three soils in question were due to retarded nitrification. The larger quantities of calcium cyanamide as well as the largest quantity of cyanate were evidently injurious to the soil bacteria and depressed the activities of most of the groups. The depressing effect of these materials may be apparent in the ammonification studies recorded in the table.

It will be noted that the ammonification coefficient for soil 1 was, on the average, 32.64. The ammonification coefficient in soil 2, with an application of 1.25 gms. of sodium nitrate was 29.03 mgs.; in soil 3 with an application of 2.50 gms. of sodium nitrate the ammonification coefficient was 33.60 mgs.; and in soil 4 with an application of 5.00 gms. of sodium nitrate, the ammonification coefficient was 41.38 mgs. We see thus that the decay bacteria in the soil were favored in their growth by the presence of sodium nitrate. Now many of the saprophytic bacteria in the soil are

capable of using nitrate as a source of nitrogen, and its presence, by increasing their numbers and vigor, enables them to attack more energetically the protein compounds of the humus. This explains in part the very large returns often secured from small applications of nitrate. Not only are the plants stimulated in their early growth by the latter and acquire thereby a better root system and a greater ability to exploit the stores of available nitrogen in the soil; but also the ammonifying organisms in the soil are stimulated and are made to furnish more available nitrogen to the crop. The beneficial influence of sodium nitrate, on soils deficient in available nitrogen compounds, is due, in the first place, to the direct supply of nitrogen to the crop; in the second place, to the better utilization of the available nitrogen compounds formed from the soil humus; and in the third place, to the more rapid decomposition of the humus, thanks to the greater numbers and vigor of the saprophytic bacteria. Field experiments may prove the practicability of applying small dressings of nitrate to the soil after the plowing under of green manures. By thus hastening the decomposition of the organic matter the availability of its nitrogen must be increased for the first, and perhaps also for the second season. Well composted manure undoubtedly acts in a similar manner by supplying not only more or less appreciable quantities of nitrate, but also enormous numbers of bacteria. The practice, therefore, of applying small quantities of manure to green crops which are to be turned under, as recommended by Schultz-Lupitz, evidently owes its efficiency to the facts just noted.

The influence of ammonium sulphate in retarding or enhancing the growth of the decay bacteria in the soil, is not apparently the same as that of the sodium nitrate. Soil 5, with an application of 1.0 gm. of ammonium sulphate, had an ammonification coefficient of 30.39 mgs.; soil 6, with an application of 2.0 gms. of ammonium sulphate, had an ammonification coefficient of 25.58 mgs.; and soil 7, with an application of 4.0 gms. of ammonium sulphate had an ammonification coefficient of 27.02 mgs. It is clear that the ammonium sulphate nitrogen exerted a depressing effect on the growth of the decay bacteria. The explanation for this phenomenon must be sought in the tendency of

ammonium sulphate, when present in considerable quantities to encourage the growth of molds rather than of bacteria. This is strikingly illustrated in culture solutions containing ammonium salts as the only source of nitrogen, besides the necessary mineral salts and sugar. Such culture solutions when inoculated with a small quantity of soil soon develop, on the surface of the liquid, a heavy membrane consisting largely of molds. On the other hand, a similar culture solution containing sodium nitrate instead of ammonium sulphate as the only source of nitrogen, when inoculated with the same soil allows the vigorous growth of bacteria and practically excludes the development of molds. There is a constant struggle for existence between molds and bacteria, as well as among the latter themselves, and the supremacy of either is determined by the culture conditions. The fact, therefore, that in the ammonification studies recorded here, the application of ammonium sulphate had depressed the ammonification coefficient of the soil, is in agreement with the evidence secured in other experiments. It has been shown by Wagner and others that the applications of lime increase the returns from ammonium salts, a fact readily accounted for, from the standpoint of soil reaction. The unequal utilization of the acid and basic radicals of ammonium salts leads to an increase of soil acidity, while the unequal utilization of the acid and basic radicals in sodium nitrate leads to an increase of alkalinity in the soil. In other words, the soil reaction is changed in the one case to favor the vigorous growth of molds; in the other, to favor the vigorous growth of bacteria.

The application of dried blood also affected the ammonification coefficient of the soil in an unmistakable manner. Soil 8, with an application of 1.85 gms. of dried blood had an ammonification coefficient of 30.88 mgs.; soil 9, with an application of 3.70 gms. of dried blood had an ammonification coefficient of 37.37 mgs.; and soil 10, with an application of 7.40 gms. of dried blood had an ammonification coefficient of 44.05 mgs. The gradual increase in the ammonifying power of the soils consequent upon the application of dried blood may be explained, as in the case of nitrate, by the stimulating action of the substance applied on the activities of the decay bacteria. There is, however, a con-

siderable difference between nitrate and dried blood in so far as the decay bacteria are concerned. The nitrate is soluble in water, it diffuses readily in the soil moisture, and is at once available to the bacteria for transformation into organic compounds. The dried blood calls for a different chemical reaction, or rather a series of chemical reactions. The bacteria must produce the proper peptonizing ferments for the transformation of the protein bodies into albumoses and peptones; and since not all species produce the necessary enzymes, it follows that a substance like dried blood must affect the bacterial relationships in the soil rather differently than they are affected by sodium nitrate. At the same time, dried blood, because of ts physical and chemical constitution undergoes decay very rapidly and is capable, therefore, of acting as a powerful stimulant for many species. It thus happens that the dried blood showed in each case a higher ammonification coefficient than was shown by the corresponding amounts of sodium nitrate.

The action of calcium cyanamide in its relation to the ammonification coefficients of the treated soils is expressed at first by an increase and later by a depression in the amounts of ammonia produced in the culture solutions. In soil 11, with an application of 2.00 gms. of calcium cyanamide, the ammonification coefficient was 35.37 mgs.; in soil 12, with an application of 4.00 gms. of calcium cyanamide, the ammonification coefficient was 47.64 mgs.; and in soil 13, with an application of 8.00 gms. of calcium cyanamide the ammonification coefficient was 40.02 mgs. We see, therefore, an increase for soil 11, a further increase for soil 12, and then a depression for soil 13. Unlike the dried blood, the calcium cyanamide was apparently beginning to exert a depressing effect on the soil bacteria when present in larger quantities. Now, it has been suggested by Behrens,[1] and also by Löhnis,[2] that the decomposition of calcium cyanamide in the soil is analogous to the transformation of urea into ammonium carbonate by the urea bacteria. There is a difference, however, in that calcium cyanamide itself as well as its transformation

[1]Deutsche Landw. Presse, 1905, p. 770.
[2]Centbl. Bakt. (etc.) 2 Abt. 14 (1905), p. 389.

products may exert an injurious influence either on the germination of the seed or on the subsequent development of the plants. Similarly, in the case of soil bacteria, large amounts of calcium cyanamide or its transformation products may exert a depressing effect. Löhnis found that pure cultures of soil organisms particularly marked for their ability to decompose calcium cyanamide, showed a rather low ammonification coefficient when inoculated into peptone solutions. It may be, therefore, that the addition of calcium cyanamide to the soil may, beyond a certain point, encourage the multiplication of certain species not normally prominent in the soil, and possessing a comparatively feeble power of ammonification in peptone or gelatin solutions. Smaller amounts of calcium cyanamide may, on the other hand, encourage the multiplication of less prominent species without appreciably retarding, at the same time the normally prominent ammonifiers.

Turning now to the culture solutions inoculated with soils 14, 15, and 16 we note at once that the cyanate had proved distinctly injurious to the ammonification bacteria in the soil. With an application of 6.10 gms. of cyanate, the ammonification coefficient was 28.31 mgs.; with an application of 12.20 gms. the ammonfication coefficient was 23.28 mgs.; and with an application of 24.40 gms. it was 18.29 mgs. Apparently the application of 6.10 gms. of cyanate had already depressed the activities of the ammonification bacteria, the depression becoming greater in the subsequent applications. Taken together with the fact that the amounts of ammonia nitrogen found in the soil itself were quite considerable, the ammonification coefficient would indicate that the injurious influence extended to most of the soil bacteria, an asumption further supported by the nitrate determinations in the soil itself.

Further evidence as to the depressing action of the cyanate is furnished by a series of pot experiments which are reported here. Each of the pots contained 5 pounds of clean pebbles and 20 pounds of air dry soil. Each soil received 4 gms. of acid phosphate, 2 gms. of muriate of potash, 10 gms. of finely ground magnesian limestone, and 1 gm. of sodium nitrate, or its nitrogen equivalent of calcium nitrate, cyanamide, ammonium sulphate, cyanate, and dried blood. Parallel pots were treated similarly

except that 2 gms. of sodium nitrate, or its nitrogen equivalent of the materials just named was employed. The soil itself was a rather fine sand noted for its low productive power and greatly deficient in nitrogn. After the proper amount of soil was weighed off for each pot, the various fertilizer materials were introduced, and water added to furnish an optimum moisture content. About 10 days subsequent to the applicaton of the fertilizers the soil was seeded with barnyard millet. The germination was not, on the whole satisfactory, and additional seeds were therefore placed some days later in several of the pots. The series of pots was arranged as follows:—

Pot No.	Treatment.			Pot No.	Treatment.		
48a,......	Nothing.			48b,......	Nothing.		
49a,......	1	gm.	$NaNO_3$.	49b,......	2	gms.	$NaNO_3$.
50a,......	0.9068	"	$Ca(NO_3)_2$.	50b,......	1.8136	"	$Ca(NO_3)_2$.
51a,......	0.8340	"	Cyanamide.	51b,......	1.6680	"	Cyanamide.
52a,......	0.7625	"	$(NH_4)_2 SO_4$.	52b,......	1.5250	"	$(NH_4)_2 SO_4$.
53a,......	2.4555	"	Cyanate.	53b,......	4.9110	"	Cyanate.
54a,......	1.480	"	Dried Blood.	54b,......	2.960	"	Dried Blood.

AMOUNTS OF DRY MATTER AND OF NITROGEN IN CROP.

Pot No.	Dry Matter. gms.	Nitrogen. %	Nitrogen. gms.	Pot No.	Dry Matter. gms.	Nitrogen. %	Nitrogen. gms.
48a, ...	10	1.75	0.175	48b, ...	11	1.57	0.173
49a, ...	10	2.45	0.245	49b, ...	14	2.48	0.347
50a, ...	10	2.43	0.243	50b, ...	12	2.22	0.266
51a, ...	12	1.97	0.236	51b, ...	14	2.12	0.297
52a, ...	12	1.96	0.235	52b, ...	17	1.82	0.309
53a, ...	10	1.78	0.178	53b, ...	10	2.10	0.210
54a, ...	14	1.40	0.196	54b, ...	15	1.52	0.228

FERTILIZER NITROGEN RECOVERED IN THE CROP.

Pot. No.	Recovered. %		
48a,....................	.....		
49a,....................	45.80	Sodium Nitrate, ...	100
50a,....................	44.51	Calcium Nitrate, ...	97.2
51a,....................	40.00	Cyanamide, ...	87.1
52a,....................	39.35	Ammonium Sulphate, ..	85.9
53a,....................	2.58	Cyanate, ...	5.63
54a,....................	14.19	Dried Blood, ...	30.9

The data tabulated above show that the cyanate depressed the yield of dry matter, and particularly of nitrogen. With an applicaton of 2.4555 gms. of cyanate the yield of dry matter was 10 gms.; while the double quantity of cyanate produced no further increase. In other words, the untreated soil produced as much dry matter as did the soil which had received an application of cyanate. By subtracting the yields of nitrogen in the untreated soil from the yields in the soils which had received an application of cyanate we secure the amount due to the nitrogen applied. Dividing the quantity thus secured by the amount originally applied we obtain the proportion recovered. It will be observed, therefore, that of the sodium nitrate nitrogen applied (1 gm. $NaNO_3$), 45.80 per cent. was recovered in the millet crop. Calcium nitrate showed a slightly lower recovery, namely, 44.51 per cent., while recovery from the calcium cyanamide and the ammonium sulphate was somewhat smaller than that from the calcium nitrate. When we come, however, to the cyanate, we find a recovery of only 2.58 per cent. Similarly, the recovery from the dried blood, though much larger than that from the cyanate, is still comparatively low. With sodium nitrate nitrogen at 100, we find, therefore, that the value of the cyanate nitrogen was 5.63, and that of the dried blood nitrogen 30.9.

As to the cyanate, the only plausible explanation of its low availability would be that the cyanate either injured the plants directly, or exerted an injurious effect on the soil bacteria. We have already seen in the ammonification experiments that the soil bacteria were unfavorably affected by the cyanate, and the assumption is therefore justified that either the injury to the bacteria, or the injury to both bacteria and plants was responsible for the low yields of nitrogen in the crop.

As to the comparatively low returns from the dried blood, the following considerations will help to render the facts in the case more intelligible. The normal availability of dried blood nitrogen, with that of sodium nitrate at 100 should be about 65. The low availability in the present experiment seems to be due to the air-drying of the soil previous to its use in the pots. It has been demonstrated in ammonification studies, reserved for publication at some future date, that the air-drying of any soil

reduces the number of bacteria to such an extent as to affect materially the bacteriological efficiency of that soil. Practically it would seem that the availability of organic nitrogen compounds after a dry season is much lower than it would be after a season of normal rainfall. The rapid reduction in the numbers of bacteria as the soil dries out is not fully compensated for weeks or perhaps months. Not all of the soil bacteria are affected to the same extent by the dessication of the soil. The nitrifying bacteria seem to recover quite rapidly, more rapidly, at any rate, than the many species of decay bacteria. It is for this reason that in the soils under consideration the availability of calcium cyanamide and ammonium sulphate was high. The transformation of these substances into nitrate is not as complicated, after all, as it the transformation of dried blood or of other organic nitrogenous compounds into nitrate. The latter are dependent on the activities of a host of decay bacteria before the ammonia stage is reached. With these facts in view, it would seem more rational to apply nitrate of soda, or sulphate of ammonia after a severe drought than to apply dried blood, castor pomace, yard manure, etc. On the other hand, after seasons of abundant rainfall the availability of nitrogenous organic substances should be greater than that in average seasons. Hence, in the use of nitrogenous substances, nitrates and ammonium salts should be given the preference after very dry seasons and organic materials should be preferred after wet seasons.

Turning back now to the table under series III, we note that the nitrates found in the fresh soil samples bear a definite relation to the nitrogen treatment. We observe that in soil 2, with an application of 1.25 gms. of sodium nitrate, there were found 53.6 parts per million of nitrate nitrogen, less than that found in the untreated soil 1. In soil 3, with an application of 2.50 gms. of sodium nitrate, there were found 100 parts per million, and in soil 4, with an application of 5.00 gms. of nitrate nitrogen, 108.2 parts per million. Subtracting the amount of nitrogen added in the nitrate we find that the latter stimulated nitrification; at any rate it did not depress it. In the case of the ammonium sulphate nitrification was slightly favored although not to

the extent that would have become apparent, had the samples been drawn two or three weeks later.

In the case of the dried blood, the results are quite instructive. In soil 8, with an application of 1.85 gms., the amount of nitrate nitrogen found was 28.2 parts per million. There was evidently a reduction here from the amount found in the untreated soil, a reduction which might be ascribed to the injurious influence of the readily decomposable dried blood. This explanation would hardly appear plausible, however, for in soil 9, with an application of 3.70 gms. of dried blood, and in soil 10, with an application of 7.40 gms. of dried blood, the amounts of nitrogen found were 53.6 parts, and 98.7 parts per million, respectively. It must be assumed therefore, that the smaller application of dried blood did not retard nitrification, but that the nitrates formed here were used up more readily by the decay bacteria in the soil, and converted into organic combinations. As to the calcium cyanamide, and the cyanate, their presence was unmistakably injurious to the nitrifying bacteria, since the amounts of nitrate nitrogen found were not only small, but were not sensibly increased or decreased in the larger applications.

REPORT OF THE BIOLOGIST.

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Report of the Biologist.

OBSERVATIONS ON THE FIXATION OF OYSTER SPAT AT BARNEGAT, N. J., 1907.

SECTION I. INTRODUCTION.

The work of the biologist during the summer of 1907, in experimental researches in the improvement of oyster culture, have yielded most gratifying results; the progress made has exceeded that of any previous season.

We confined our attention to the study or natural spatting in a single locality, viz.: the lagoon at the mouth of Barnegat creek.

The discoveries made have considerably modified the outlook on the future developments of these experiments; some of the things that we thought would be easily accomplished, when once their secrets were unfolded, are now seen to be difficult. On the other hand, we have secured results that appear capable of immediate application for the benefit of the practical operations of the oyster industry on a commercial scale, though in a direction somewhat different from that in which we had hoped to succeed. The outlook for the artificial propagation of oyster seed is less encouraging, whereas, we hope to be able to improve our methods of catching natural spat. However, we must not conclude that the old quest of our researches is impracticable. It will simply be a great task to work it out.

SECTION II. INCREASED APPROPRIATION.

The act of 1901, which provided for these experiments, limited the amount that could be appropriated to the sum of two hundred dollars per year. The State Legislature, which convened in the

winter of 1907, revised this act, increasing the limit to twelve hundred dollars; this amount was placed in the supplemental appropriation's act for 1907. Thus has this important work been put on a basis that allows of operations adequate for the end in view, and widens the scope of the experiments. Oyster culture has now its proportionate recognition, with general agriculture, in the activities of the experiment station, and is destined to share proportionately in the improvements that result from scientific researches.

The greater portion of this appropriation has been used to provide a part of the much needed equipment. The amount was not sufficient in a single season to meet all the needs that had arisen, to secure the necessary apparatus, or to enter fully on the plans that had been considered.

Whatever of value may result for the improvement of oyster culture from the better facilities afforded, and the increased encouragement given our researches by this generous act of the State of New Jersey, should be credited to the efforts and influence of many friends of this important industry; from Senator Hand, who introduced the bill, to Governor Stokes, who signed it; particularly the members of the Legislature from the maritime counties, who upheld it, and the Appropriations Committee, etc., who reported it favorably.

SECTION III. THE POWER BOAT.

The most urgent of our needs was a convenient means of reaching all parts of our field of operations. This need has been met by the construction of a suitable boat, which has to do the duty (1) of a runabout, (2) of a temporary laboratory for simple operations, and (3) of a tug to draw the floating laboratory, which is yet to be provided.

The specifications called for a draught not to exceed thirteen inches, and a stability such that walking about in her should not tip her enough to spill the contents of the experimental dishes. Her length should approximate twenty-one feet, and breadth seven feet.

She should have a cabin at least six feet in length by five and a half broad, leaving deck room outside to allow passing forward. The cockpit should be seven feet in length with a stern deck eighteen inches long.

She should have supplementary sail power and center board.

The capacity of her naptha engine should be at least five horse power, so she could pull the floating laboratory.

These and other specifications were met in the construction of a cedar boat by J. H. Perrine, of Barnegat. The hull is a bateau model with nearly flat bottom.

As the light draught thus provided for, would be sacrificed by using a large propeller, it was decided to install two small propellers, each of six inch radius, and also to divide the power, between two small engines, rather than have one engine work both propellers by means of gearing.

We thus gained an important advantage, in that a breakdown became a remote possibility; one at least of the three sources of power might be expected to work in any contingency arising.

This boat was not ready to launch until near the close of the season's experiments, late in August. A few days of early September were spent in testing the boat and becoming acquainted with her management. Naturally this experience suggested some improvements, though on the whole, the boat seemed well adapted for the work for which she was planned. We found, however, that the propellers were too small to permit of the full utilization of the power of her engines, so that the chief change to be made is the substitution of three-bladed fourteen-inch wheels of moderate pitch for the two-bladed twelve-inch wheels of high pitch originally provided.

SECTION IV. SCOPE OF THE EXPERIMENTS.

We determined to confine our researches to a study of the fixation of spat, the Barnegat region being well adapted for such study. But even when so limited it became necessary to supplement such studies by several series of allied observations. Therefore, the daily routine embraced: (1) making a record of the tides; (2) the temperature of air; (3) of water; (4) the specific

gravity of the latter; (5) the filtering of samples from different localities, and (6) the examination of the residue for the presence of oyster fry; (7) the examination of the grown oysters to ascertain the stage of the ripening of their eggs and the progress of the spawning process; (8) the fertilization of eggs and the rearing of the young during development; (9) the planting of these artificially produced fry in enclosures with shells to which they could become attached; (9) the placing of shells and other cultch to catch natural oyster spat, and (10) the quantitative estimation of the various results, and judging their mutual relations.

Thus there was work enough to keep us occupied all the time; and we were engaged in these researches more continuously than in any previous season. The results secured are of great importance and practical value, as they will enable us to plan co-operative experiments with the oyster planters in placing shells for catching spat for seed. The data secured have been compiled into a series of tables that supplement the journal of operations.

SECTION V. THE BACKWARDNESS OF THE SEASON.

The spring of 1907 will be remembered as unusually cold; and June was declared by weather observers to have been the coldest known in seventy-five years. It was the opinion of experienced oystermen that "the oysters were fully three weeks behind in the maturity of their spawn." We were, however, surprised to find that the water near the laboratory had reached a maximum of 70 degrees Fahrenheit early in June, and by the 22d registered 84 degrees. This state of affairs is to be explained as the result of the absorption of the sun's rays by the dark mud of the shallow creek and lagoon during bright days, and the rapid warming of the thin layer of water above. The water on these flats, therefore, warmed up rapidly and hastened the ripening of the relatively few oysters found thereon. These oysters were few, because of the severity of the preceding winter, the accumulations of ice, and also the accumulations of rotting eel grass. Nearly all the seed of 1906 died on the flats, and a large proportion of the adult oysters, even in deep water, succumbed.

There were a few oysters ripe and spawning in June, and after the warm spell began in mid June free swimming oyster fry were present in limited numbers. It was not until July 5th that spawning was general, and soon thereafter the water was swarming with oyster fry. This climax in spawning occured about three weeks later than usual.

It was not until near the end of the month of July that an abundance of spat was seen, whereas the usual date for this event lies between July the seventh and tenth.

Several of the planters placed their shells during June, while others waited until July. Still others planted a few shells from time to time. Long experience has served to establish a date for shell planting that lies in the latter part of June, or at the latest, during the first week in July. It is well known that the young oyster requires a clean surface to attach itself to, and that soon after being placed in the water, clean shells become coated with a slimy deposit, consisting of mud and a growth of microbic vegetation. This prevents spat fixation. If shells have been in the water a much longer period, they acquire a thin coating of firm texture, on which the young oyster "sets" readily; but very few shells after so long a sojourn are exposed for spat fixation, because most are buried in mud. Hence, the importance of placing shells within two or three days of the time when the most oyster embryos are ready to set.

Evidently this was not done last summer. Past experience offered no guide, and nearly all the shells were down several weeks before the spatting season had begun. Hence there was only "a small catch" the present season.

Had the planting of shells been guided by a scientific study of the development of oyster fry in the water, by expert examination, it seems certain that much better results would have been scured.

SECTION VI. THE FILTRATION STUDIES.

Oyster fry, at the time of "setting," are too small to be detected except by means of microscopic magnification. The water swarms with particles whose average size is greater than that

of the young oysters. Many of these particles are the young of other animals, the most abundant are the copepods and other small crustacea, e. g., the young of shrimps, etc. Next most numerous are the young "veligers" of the many small snails that are everywhere in the black mud. The young of the red worms that crawl over the oyster shells are also abundant. To distinguish these various objects requires a power of at least fifty diameters magnification. With such a power only a drop of water can be examined at one time. Now, if only a single oyster fry is present in a bucketful of water, it means the presence of thousands, yes, millions of fry in the entire water area; yet to discover this would require more arduous labor than to find the proverbial "needle in the haystack."

It therefore becomes necessary to filter the water through a strainer fine enough to retain the fry in their youngest stages, and, naturally, all the coarser particles are also retained. The residue must not become too concentrated, or the few oyster fry present will be buried in the sediment, and be undiscovered.

Daily, and several times daily, did we strain samples of water from different localities and examine the residue. If the water was turbid from the presence of a current, or of waves, due to a stiff breeze, our work was practically lost, but otherwise we succeeded in capturing the lone two or three, or even one, fry present in a bucketful, or a bowlful, or a dishful of water, as the case might be. In every case, all the sediment properly diluted was examined drop by drop and the fry counted, the results are shown in Table IV. The material which was found to be the best strainer for this purpose is a filter paper, specially adapted for straining agar. This is "rapid," but sufficiently fine to retain all the fry. Yet its pores do become clogged by the finest sediment, and the operation of filtering a bucketful of water often requires an hour or longer. At first we did not realize that the oyster fry would cling to the sides of the filter, as the water surface subsided during filtration, but soon we found it necessary to constantly wash the exposed surface of the filter above the water. It took longer to discover that more sediment and fry accumulated under the folds of the filter than on the exposed surface. Hence, a perfect filtration required that

the filter be unfolded and its entire surface be washed into the residue. This meant a larger quantity of residue to examine and much tedious work.

It is usually stated that the developing oyster swims around in the water about a week, or less, before it "sets" on cultch. Last year we were inclined to believe that the interval of free life was less than two days, and we felt that this view was not only corroborated by our own observations, but also by those of Colonel Macdonald, the lamented brilliant chief of the United States Fish Commission.

Our studies this year seem emphatically to negative such views. The fry, at the time it becomes spat, is about sixty-fold greater in bulk than when it first gets a shell. The shell appears so quickly, in fact on the same day the eggs are extruded, that it is rare to see developing oyster eggs that have been naturally fertilized. All the fry found are in the shell stage. The small ones are most numerous, and the larger ones least so, thus showing a great progressive destruction of the fry during growth. This growth is slow. By carefully plotting the relative abundance of fry from day to day, and the number of spat seen, we find that the first climax (see the Tables and Plate I.) in the presence of oyster fry extends from July 5th to 10th; whereas the first climax of oyster spatting occurred between July 23d and the 30th, an interval of nearly three weeks from one climax to the next. A considerable number of spat set as early as July 15th, and it is possible that these belong to the fry hatched the week before. More extensive observations will be needed to determine the true interval. This we hope to work out next year.

SECTION VII. SPATTING OBSERVATIONS.

The problems of ascertaining the time of the occurrence of spatting and the distribution of this process, in relation to tides, alternation of day and night, calm and storm, etc., called for much thought and planning. We confined ourselves mainly to the use of oyster shells as cultch. These, after all, are the main reliance of the oyster man. The objection to their use in ex-

periments is the great difference in size, shape, character, etc., of the different shells. When one shell receives a fine "set" of spat, while another next to it receives few or none, how is such a difference to be explained, except that the microscopic surface of one shell is more attractive to the fry than is that of the other?

We also used glass slides to a limited extent; they were all alike in size and shape, and were placed in two principal ways, either fastened in a slit in the upper end of a cedar shingle projecting upright out of the mud, or they were placed horizontally across the hollow of the deeper valves of the oyster shells. These glass pieces seem to be favorite places for the growth of "slime." They quickly received a considerable layer of sediment. Some of them became coated with a firm, dull layer, resembling the albumen or gelatin film on a photographic negative. These were far more attractive to spat than were the clean slides. In fact, the spat seem to avoid setting on absolutely clean glass or tin. They even prefer the rough, horny surface on the outside of a bivalve shell to the smooth, pearly surface within. But after the shell cultch has become old and green, it is a good place to "set," provided it is microscopically smooth. A rubber boot or an old painted surface offers a favorable surface.

The following places were chosen for planting shells as spat collectors:

(1) At Horace's Point, north end of Conklin's Island, opposite the public dock. Here is the outlet into the bay of the northern exit channel from the lagoon and creek. Here the water flows rapidly over a bar, and shells placed there get the best set. A wire basket was made to hold the shells to keep them distinct from those planted at this point by Captain Ridgway. A bulkhead of slabs was built during the summer along the bar, throwing the current farther out, and at the end of this bulkhead we also planted shells.

(2) To the east of Cat Islands, well to the south of Shad Point, which point marks the entrance from the lagoon to the north exit channel. Here we erected a crate consisting of two "decks of galvanized wire. The space between the decks was

enclosed by wire netting provided with doors. Near it was placed the cedar shingle that held the glass slides. Here the depth of water is less than a foot on extreme low water, and less than three feet on higher tides (excepting storm tides).

(3) At the east end of Little Cat Island. At this point the water is very shallow, and is a good place for catching spat on shells. Here we installed a wooden box, eighteen inches wide by three feet long, a foot deep, and divided into two equal compartments. The box was made of cedar laths, leaving narrow cracks between, so that the water would readily rise and fall inside the box in correspondence with the tides. The box was fastened so that it was under water on the highest tides.

Near by we floated a shallow box, made on a similar plan and of similar materials. In each box one compartment received accessions of the natural fry obtained by filtration, and the other was stocked by artificially fertilized fry. Both compartments could readily lose the fry placed therein, and both could receive natural fry from the entering water. The chances that the cultch placed here would be "spated" quite alike, were very great, nevertheless, there was a striking difference in the numbr of spat prsent in the two compartments, and the results harmonized in both boxes.

(4) At the western end of Little Cat Island, where the water was deeper, here we placed a floating cloth box, which had been used in previous experiments unsuccessfully for two years. The cloth was so closely woven that oyster fry could neither leave nor enter. This had two compartments of a size equal to those in the wooden boxes. The cloth walls became heavily coated with slime. Experiment had shown that the water in this box would not remain in first-class condition, there being a lack of sufficient circulation. That is the reason the boxes with the cracks between the slats were installed, although these cracks permitted the passage of oyster fry.

The cloth box was treated just like the wooden boxes, except that its load of shells was removed once (July 18th), when it was cleaned. At the time of examination, August 2d, the oldest shells were from July 19th. The results were quite in harmony

with those secured at the wooden boxes, but the total number of spat was much smaller. Each day all of these places received a planting of dated shells. It was found that the little black snails crawled over the shells and licked the pencil marks, rendering them obscure and hard to see after a few days. At the crate the shells were removed at intervals; at the other places they were allowed to accumulate until August.

The crate experiment involved the placing of shells daily, and their removal at such times that each day offered shells that had lain six, twelve and twenty-four hours respectively. The six-hour shells represent forenoon and afternoon intervals, and the twelve-hour shells day and night intervals. Shells were also planted for daily intervals, up to the fourteen-day period. The problem of interpreting the results obtained on these shells is no easy one, as the fry was setting all the time, but irregularly as to abundance. Nevertheless, from the data incorporated into the table we get general indications. See the explanations of the Plates, II., III., IV., V.

SECTION VIII. SUMMARY OF RESULTS.

In spite of an unfavorable season, we obtained light on a number of questions of first importance, although it is desirable that these experiments be repeated with greater care to learn, more exactly, the lessons they teach.

The water and weather did not become generally warm enough to provoke spawning until after the middle of June, and the climax and completion of the first spawning period fell about July 5th.

The eggs developed so rapidly that filteration of the water showed the presence of oyster larvæ, practically, only after they are in the shell stage. In this stage, called the proctoconch stage, there is steady growth for at least a week, and possibly three weeks, with a great loss by death, until the fry are ready to attach themselves to cultch.

The fact just mentioned has been shown by direct observation of the fry found by filtering the water daily; it was also indicated by the fact that the fry were present in greatest abundance be-

tween July 5th and July 9th, and that spatting was first noticed July 21st, and most active from July 25th to the 29th or 30th.

At the time of "setting" there had been an increase in bulk, approximately, sixty times that of the young in the first protoconch stage, and the two valves of the shell, though at first equal, have by this time become unequal, the umbo of the left valve being more prominent than that of the right.

The fry settles down on the surface of the cultch on the velum and mantle folds, and cements the edge of the left valve fast to the cultch. Then there is added a fringe of shell to both valves, that of the left being cemented fast to the cultch. At the hinge this so-caled silphologic addition proects in a straight line on each side, inclined at an angle to each other. These silpho additions are repeated constantly, enlarging the size of the shell, until by two weeks an area, 3 millimeters in diameter, is covered. At first the silpho additions are placed symmetrically, but after a month or longer there is a dorsal curve in the direction of growth, and also a curve upwards, *i. e.*, a bend of the right valve away from the cultch, followed by the left side; and, thenceforth, the new growths on the edge of the left valve are not attached to the cultch.

Experiments in the artificial propagation of oyster fry did not succeed until the oysters were spawning.

Only those lots that developed a protoconch were considered to have been successful.

These were planted on shells in boxes with central compartments in which natural fry were placed. From two to three times as many spat were caught in the compartments receiving artificial fry as in those receiving natural fry.

Most of the shells planted by oystermen were placed too early, so they became coated with dirt, which prevented an abundant set. The average set in the Mullica, on planted shells, was less than two spat per shell, very few shells having over six spat.

In our experiments involving daily plantings, the best shells caught from one hundred to over two hundred natural spat in from three to five days.

The young spat can be recognized by means of a magnifying glass, from the very hour it becomes attached.

By means of the filteration of sea water it is practicable to keep record of the development of natural fry, so that the date when shells should be planted can be quite accurately determined.

SECTION IX. JOURNAL OF SPAWNING, AND FILTRATION STUDIES.

June 7th.—At Barnegat. We painted the rowboat; tides run extra high.

June 8th.—A stormy day.

June 9th.—At Tuckerton. Investigated the condition of oysters, and found that none contained spawn sufficiently developed for experimental purposes, except the East river plants.

June 10th.—At Barnegat. Investigation of oysters taken from the bay a week earlier, and placed on Hollingsworth's float, showed no spawn present.

Many of the oysters at Cat Islands and in the bay had died the previous winter. The fine set of spat of last season was mostly killed. The natives at Cat Islands contain well-developed spawn. We conducted fertilization experiments on Lot V. Opened 150 oysters from Hollingsworth's float, and found spawn in ten to fifteen per cent. of them. Planted some at Laboratory Point.

June 13th.—Filtered water, but found no oyster fry.

June 14th.—Northeast storm raging, and tide overflows the meadows. This water on filtration showed the presence of a couple of little bivalve fry smaller than oyster fry.

June 16th.—Filtration of water from Cat Islands showed the presence of small bivalves, possibly oyster fry, and a large one resembling a quohaug, which was probably an oyster fry grown ready to set as spat; but it seemed to be dead. Prepared a tide gauge.

Examination of native oysters at Cat Islands shows some ripe ones among many not yet matured for spawning. The latter contain much fine granular material mixed with the eggs. A number of these were planted at Laboratory Point.

A fertilization experiment was made from the former (Lot VI.) and distributed among three dishes, one of which was placed in a float to keep the temperature from running below 70° during the night.

June 18th.—The tide is extremely low, both air and the water register 70° Fahrenheit.

The dish in the float had been submerged so all the fry were lost; those kept in the laboratory were decomposing, having failed to reach the shell stage of development.

June 19th.—Prepared fertilization experiment from Lot VII. Made a wire basket to hold shells for cultch and spat experiments. Placed this at Horace Point, north end of Conklins island, opposite the public dock. This is the most favorable place for catching spat, as nearly all the water that ebbs out of and into the lagoon must flow rapidly over the bar at this point.

Examination of shells recently planted by Captain Ridgway at Horace Point shows no spat present. Filtration of the water flowing over the shells show no fry.

June 20th.—No fry is present in the water to the east of Cat Islands.

The eggs fertilized yesterday have developed into a fine shell stage.

June 21st.—Natural oysters at Cat Islands show on examination that the smaller and younger individuals are further advanced than are the larger older ones in regard to the maturity of their spawn.

The residue on the filter to-day shows the presence of oyster fry, but it is a question whether they are natural or only accidentally introduced by contamination from utensils (dishes and pipettes) used in the fertilizing experiments. Hereafter we will reserve utensils for exclusive use in filtration experiments.

Prepared a crate (described elsewhere in this Report) for cultch and spat observations, and placed it east of Cat Islands. This crate of galvanized wire netting permitted free flow of water through it, and had two wire net decks, one at level of mud bottom, and one a foot above. Clusters of natural oysters were placed in its immediate vicinity.

Fertilized Lot VIII., the oysters being opened on the grounds and brought to the laboratory for the manipulations of the experiment. The lot failed to develop properly; no doubt due to the delay in infusing the spawn.

June 22d.—Clean oyster shells as cultch were placed on both platforms of the crate, and this crate, the basket at Horace Point, and other floats, boxes and platforms hereafter installed, received such accessions daily until mid-August, which routine will not be repeatedly mentioned in this journal. Similarly, the filtrations also occurred daily. (See Tables.)

Fertilized Lot IX., but the spawners were not perfectly ripe; they were opened on the grounds and the spawn infused for the two sexes into separate dishes, and the eggs washed twice before addition of the sperm water.

Made a cloth box float, with two compartments, and anchored it at the west end of Little Cat Island.

June 23d.—The air on a southeast wind is 70° Fahr.; but the shallow water over mud flats has been heated by the sun to over 80°, and it steams tremendously, producing a drifting fog that obscures vision in all directions—a most interesting sight. Doubtless the wind is already saturated with moisture from its ocean voyage.

The direction of tidal currents east of Cat Islands is north and south, while west of these islands it is east and west. This is due to the position of the north exit channel relative to these respective localities.

Many larvæ of annelid worms are present in the water.

June 24th.—Performed fertilization X., but lost most of the material late at night. Several of the oysters have now completed spawning. Such oysters have coarse granules and broken down eggs among the remnants of spawn in their ovaries. The spawn not quite ripe, or possibly quite so, is viscid when pressed from the oviduct. This is not the condition when the eggs are spawned naturally, for then each egg is separately wafted out of the egg tube by ciliary action.

Examination of shells near Horace Point, left from last year, and containing spats a year old, shows that these young seed oysters average an inch in diameter, and contain spawn in amount proportionate to their size.

June 25th.—The water contains a host of snail larvæ that tend to collect on the surface in calm weather, similar to many other larvæ, including annelids, Copepods and other entomostraca.

The water contains large oyster fry that look like clams; they are grown nearly large enough to set as spat. They were found in water secured from several different parts of the lagoon.

The oysters in the upper part of the lagoon have spawned. A fertilization of Lot XI. gave poor results; perhaps due to delay in opening the oysters.

June 26th.—The tides now run extra high, it being full moon, and the flood tide occurs between ten and eleven o'clock.

The water secured for filtration was permitted to stand awhile in the bucket; then the top was carefully skimmed off and proved to be filled with the various larvæ above mentioned, but no oyster larvæ. On the other hand, the sediment at the bottom of the pail contained oyster larvæ. These were also present, especially the large ones, in the water at some distance above the bottom. The explanation seems to be that the presence of a shell weighs the oyster fry down. The snail larvæ also have a shell, but project a part of the body out into the air which is held up by the slime and surface film. The large oyster larvæ are stronger swimmers than the small ones.

This observation suggested the filtering of water that was in agitation, thus bringing the oyster larvæ into the water taken, which, being dipped up with the bucket, is mostly surface water. Accordingly, in the north exit channel near the San Souci, when the current was swirling past the rudder of an anchored catboat, a pailful was secured. But this contained so much debris that it was impossible to see the larvæ. A sample from calmer and, therefore, clearer water showed the presence of oyster larvæ.

Then an apparatus was prepared to secure water from near the bottom, where the water was not so turbulent, yet where the current would bring the fry, as at Laboratory Point. The first haul showed the usual percentage of oyster fry, but, suspecting contamination, three subsequent hauls were made and no oyster larvæ were found.

June 27th.—Samples of oysters planted at Laboratory Point, as described earlier, were taken, found to have begun spawning, and fertilization XII was made, the eggs being infused 20 minutes before the sperm water was added. This experiment resulted poorly.

The surface water at Laboratory Point contains many snail larvæ and a few oyster larvæ; the latter were found in the sediment of the bucket. Why the oyster fry should be at the top in their native haunts, but not in the quiet water of a bucketful, might be explained partly by the theory that the bright light of sky above (not present in the laboratory) attract the larvæ, and partly that the water, being in motion, both by waves and currents, tends to buoy them up.

June 28th.—A calm morning, and the water in the channel near Sans Souci being clearer, its filtration showed the presence of oyster larvæ. At noon the surface of water at Laboratory Point was agitated by waves, and shows the presence of oyster fry on full tide. In the late afternoon at low tide the water at this point showed no fry.

June 29th.—Oyster lot XIII., secured west of Little Cat Island, showed ripe spawners; a fertilization experiment was tried, which resulted poorly. Filtration trials resulted poorly to-day; there was much sediment produced by the agitation by a northeast storm.

June 30th.—The water is still too turbid to give good results in filtration trials.

July 1st.—Examination of shell cultch shows absence of spat.

Fertilization experiment of Lot XIV. from mid-lagoon, conducted carefully and with apparently good spawners, resulted poorly. Shells in box, and especially in box float, are covered with dirt and a growth of "green moss" algæ. These boxes were placed at lower end of Little Cat Island June 24th.

July 2.—Filteration experiments show an increase in the proportion and size of the large oyster fry. What seem to be oyster eggs are also present, but, as these quickly get shells, the chance of seeing them is small, and our filtration results accord therewith.

July 3.—Fertilization of Lot XV having a good lot of large spawners (the small ones have become empty) was conducted by infusing the spawn of the two sexes separately into glassfuls of water as fast as opened instead of opening all first. Every five minutes during the performance sperm water was added to the eggs. Some were kept in the laboratory and some on the float,

as the nights were cool. Two days later the lot was discarded as worthless.

July 4.—Filtration of water from Horace Point on late ebb tide shows absence of fry, though some were present at Cat Islands, near the crate.

The cultch from Horace Point, carefully examined, shows no spat attached. Found a large clam larva with a heavy, long, lash-like "foot," reminding one of a Beach clam (*mactra*); oyster fry are increasingly present.

July 5.—A half pailful of water taken near the laboratory shows forty oyster fry. The morning was warm and calm, and tide half ebbed. Later in day (at noon), as usual, a strong south wind sprang up and raised much dirt into the water, but the fry are so abundant that 18 were counted in the sediment. Two hours later no fry were found in water filtered from this locality, nor again four hours later at low water on turn of the tide.

At crate we opened oysters and found about all spawned, or else spawn remained only in the males. Made fertilization in the boat on grounds from one female, Lot XVI. Night was cool. This lot developed finely, reached the shell stage, and was planted in the boxes as described elsewhere.

July 6.—Prepared fertilization experiment. Lot XVII., from Laboratory Point, where apparently good spawners were present. The eggs received three accessions of sperm water at five-minute intervals, and were distributed into three dishes. The lot turned out poorly, partly due to lack of proper separation, and was discarded next day. Examination of Lot XVIII. from same locality as the successful Lot XVI. was made. The large oysters seem to have fully spawned out; the young oysters have the most spawn. Probably the latter are now coming a second time into spawn. The lack of good material made us abandon an attempt at fertilization.

Filtration of water in remote part of lagoon, where current scarcely ever arises, shows the presence of fry.

July 7.—A calm morning, but soon a breeze started. We skimmed (7.30 A. M.) the surface of the water at Laboratory Point, and left the water standing in the pail a couple of hours. Then we skimmed its surface and got 7 fry in the first dipperful and

2 in the second. Then we poured off the water from the pail until only two dipperfuls remained. The first of these contained 3 fry, and the second 25. A kettleful (one-third of a pailful), secured from the mid-lagoon at 9.30 A. M., was skimmed after standing, and a half-dipperful yielded 3 fry. Then all was poured away except a half-dipperful, which on filtration yielded 8 fry.

The surface of the water near Laboratory Point was now becoming rough from the wind, and a pailful was secured at 10 A. M., a few rods from shore. This, on standing a short time, yielded 14 fry from the bottom two dipperfuls.

Near noon another pailful was secured from the same locality; was all filtered, and contained much sediment, so it took a long time to examine. Forty fry were counted.

Toward evening the wind died down, and the water was only slightly rippled. A pailful was secured near Laboratory Point, but was lost by the breaking of the filter. Another pailful was secured at dusk that yielded 47 fry. A tumberful secured at the crate contained 3 fry.

A bowlful (one-fourth of a pailful) was secured near Laboratory Point in the calm of early twilight; the upper half was poured off late in the evening, and the lower half filtered during the night. Its residue yielded 105 fry. A dishful secured at Laboratory Point (one-eight of a pailful), treated similarly, gave 25 fry.

Glass slips had been placed several days ago projecting into the water, a foot above the bottom outside of the crate. These slips were now covered with a gelatinous growth of unicellular algæ; one side was cleaned and the slips returned.

July 8.—The paper used to filter the samples secured in the calm of yesterday evening was now unfolded, and the sediment caught beneath the folds was washed out and the fry counted; the number secured was 233, or fully as many as were secured by the ordinary process (described elsewhere). It is evident that we have now a climax in the abundance of fry, corresponding to the climax in the spawning of the large oysters, noted July 6.

This morning (6 A. M.) before the breeze became strong a pailful of water was taken by skimming a few rods off Laboratory Point, and a bowlful near the Point. These were allowed to set-

tle and the debris examined, yielding 25 and 45 fry respectively, but we did not wash the folds of filter.

A pailful, secured at Laboratory Point (10 A. M.), was filtered and the entire filter washed, yielded 63 fry. A pailful secured off a ways from the Point at 6. P. M. yielded 18 fry without washing the fold. In these cases the supernatant water was poured away, and only the last dipperful or two of the bottom was filtered.

See tables for tidal conditions at the various hours when these observations were made.

July 9.—In a strong northwest wind; got water at Horace Point at 7 A. M., and secured 55 fry without washing the fold. A pailful secured off Laboratory Point at 9 A. M. yielded 11 fry under similar conditions.

The filter used in the last three filtrations was opened and washed, and yielded 52 fry. Shortly after ten o'clock a pailful of surface water from Laboratory Point yielded 25 fry without washing the folds. Another pailful taken at low water yielded 21 fry without washing the filter folds.

July 10.—A pailful of water, skimmed from the calm surface, a distance from Laboratory Point, at 7 A. M., sedimented, and the bottom portions filtered, yielded 223 fry without washing the folds. A second pailful, two hours later, on high tide, gave only 15 fry without washing.

Water from Horace Point at 10 A. M yielded 28 fry, fold not washed. Two sizes of embryos are seen among these fry. The large ones correspond to an earlier spawning, the smaller ones to a more recent spawning climax.

Fertilization of Lot XIX. was effected out in the bay, in Hollingsworth's garvey, into which oysters were being tonged for market. Specimens well filled with spawn were easily secured. They seem to have begun spawning. The sperms were first infused, then the eggs, which were washed twice before adding the sperm infusion; the fertilization being repeated three times with five minute intervals.

The eggs developed to the shell stage, and were planted in the boxes.

At 2 P. M. a pailful of water was secured at the crate (the water

was rough), sedimented, and then filtered during the night. Next morning 24 fry were counted. The specific gravity of the water at different places was determined, and found to increase regularly from the laboratory towards the bay. On high water the difference was slight, 1.006 and 1.008, respectively, at 80° and 79° respectively. But while the bay water was practically the same also at low water, the water in the creek by the laboratory was then only 1.002 at 84°. A lot of new filters arrived.

July 11th.—At 7 A. M. water secured at Laboratory Point yielded 14 small and 7 large fry (washing filter added 9). On washing the old filters of yesterday we secured 33 small and 29 large fry from the latest observations, and 130 fry from the one that had yielded 223. These papers had become dry, and the fry were dead, each having an air bubble inside.

The filter last used, on July 9th, yielded 51 fry.

July 12th.—The high southwest wind yesterday evening swamped my cloth box float and introduced much sediment. We bailed out half of the water and put on a cover.

At 9 A. M. water was taken at Horace Point, which was filled with sediment, and only 4 fry seen (fold washed). At noon, a dishful and bowful of water were gotten near Laboratory Point, but yielded only 6 fry.

At 7 P. M. the calm surface was skimmed at different points in the lagoon, and 5 small and 2 large fry counted. A bowlful from Laboratory Point gives only one larva. These larvæ were quite large.

July 13th.—A dishful of water (Laboratory Point) at 8 A. M., just as the water was becoming ruffled, yields three large fry. At 10 A. M. a pailful from the same locality gave 9 fry, three of which were large, and had a symmetric umbones. Water in calm lee of Horace Point yields 5 fry.

Fertilized lot XX, using bay oysters from a garvey load just landed. The spawn seemed good and resulted in shell development, and part of the fry were planted in the boxes, but those kept, died soon.

July 14th.—Oyster lot XXI, at Laboratory Point, gave us some spawn that was fertilized artificially, and raised to the early

shell stage, but it soon died and was discarded. Before death these fry gathered on the side of the dishes towards the light.

Water from Horace Point on early ebb gave 13 fry, mostly large and symmetric ones.

July 15th.—A cool morning; a strong northeast wind blows all day.

July 16th.—Water secured in the calm morning, near Laboratory Point, contains only 2 fry. At 11 A. M. the tide running in; water at Horace Point shows only 2 fry.

July 17th.—A warm morning. At 3 P. M., when tide first begins to flow up, Horace Point water shows only 1 fry.

July 18th.—At Horace Point, 8.30 A. M., with tide gently running out, near low water, filtration shows 29 small fry.

Fertilized lot XXIII., in the bay. The spawners did not look so satisfactory. The eggs were infused and washed too long before fertilization, so the results were not good, though the shell stage was reached and fry were planted. Examination of shells planted as cultch, showing no spat, we removed all shells placed in wire basket prior to July 10th, and all in cloth box, cleaned the latter. Filtration of water, 7:30 P. M., near Laboratory Point, shows 10 small and 1 large fry.

July 19th.—At 6 A. M., repeated examination of Laboratory Point water, and saw 12 small and 2 large fry. At 10:30 A. M. the tide coming in, the water of channel near Sans Souci contains much sediment, filtration gave 15 fry. At 11 A. M. the water near Laboratory Point gives 16 fry. At 5 P. M., Horace Point yields 19 fry on high water. Careful examination of the shells brought up yesterday shows one spat on a shell planted July 9th in the wire basket.

At 7 P. M., water taken in north (lee) side of Little Cat island yields 101 fry of all sizes, mostly small.

July 20th.—At 6 A. M. the water up the creek above the Laboratory shows 16 fry. At noon found 31 fry in water west of the boxes. At 4:30 at Horace Point, with tide coming in full, we found 28 fry.

July 21st.—At 2:30, in first of inflow at Horace Point, we found 14 fry.

SECTION X. JOURNAL OF SPATTING OBSERVATIONS.

July 21st.—Most of the shells placed daily in the lower compartment of the crate were removed to-day, and good sets of spat, less than one week old, were on three-fourths of them. A glass slide from the same place held a young spat, as also a slide on the shingle outside the crate. A piece of broken lamp chimney held 3, another piece 7 spat.

Spat were found on shells placed on the 19th and on the 20th that had just set.

Filtered water in the calm evening, from near Laboratory Point, and got 49 fry, of which many were large.

July 22d.—Again was water filtered in the calm morning from the same point as last night, and 23 fry found. Two hours later (8 A. M.) a breeze was rippling the surface, and only 7 fry were found on filtration. An hour later the observation was repeated and 6 fry found; the breeze was only a gentle one. A dishful from the crate yielded 12 fry, large and small, and from Horace Point, on ebb tide, at 1 P. M., we got 2 large, 2 medium and 3 small fry.

Examination was made of the cultch from the top deck of the crate. One of the slips of glass had a peculiar coating on one side, resembling the gelatin coating on a photographic negative; this side held the most spat.

With the exception of one, the mytilus shells held no spat. They were set on the outside, on the horny, rather than on the nacreous side.

All the shells placed earlier than the 20th in the wire basket at Horace Point were examined, and they show a few spat, most on ones placed on the 15th.

Of the shells that came from the upper deck of the crate, one placed July 13th held over 30 spat.

July 23d.—Handling the glass slide destroyed the newly affixed spat. One of the new, clean glass slides caught one new spat, whereas the dull side of the coated slip had caught 2 additional spat. In twilight, water was secured near Laboratory Point, which yielded no fry except in the sediment, where were 7 large and 2 small fry.

July 24th.—At 9:30 A. M. water from the crate yielded 22 small fry, and at 9:30 water near Laboratory Point yielded 246 small and large fry. At 3 P. M. a shell planted last evening showed one spat not yet in silpho stage, and a shell planted this morning at 9:30 o'clock has also one spat; this shell had been in the water less than six hours. A shell placed yesterday at 9 A. M. shows 2 spat in the silpho stage, and 20 others. A flat shell planted on the evening of July 22d held 15 spat on the rough side and one on the smooth inside. A flat shell planted in the morning of July 22d held 23 spat on the rough outer and 2 on the inner side.

There are 11 spat on a shell placed on the evening of July 21st, but they seem not to be further advanced than those on later shells.

The pieces of glass with dull surfaces caught more spat than those with smooth and clean surfaces, and more than the shells. Fewer spat fastened to the cultch on the lower deck than on the upper.

July 25th.—Water in the creek off Laboratory Point yields 14 fry at 7 A. M., and 7 fry at 8:30 A. M. Water from the crate at 10 A. M. yields 77 small fry. At 11:45 A. M., on third trial, a bowlful at Laboratory Point yields only 3 fry. At 4:30 P. M. water from this point yields 10 fry without washing the filter fold. At 6 P. M. a dish of water from the crate yields 14 fry, the fold not washed. A bowlful at Laboratory Point gave 5 fry, fold not washed. Used same filter for last three lots of water. On washing the folds we obtained 1 large, 7 medium and 70 small fry. A slide holding spat from the crate had been planted at Laboratory Point, but they did not survive; neither were any new spat caught here.

An attempt to study the rate of flow of the tide in the lagoon did not succeed, as the wind carried the float against the very gentle current, but enough was observed to make it reasonable to suppose that a large proportion of the fry in the lagoon never get carried out of its boundaries.

All the shells at the crate were now removed and a fresh lot placed on both decks.

July 26th.—Tide now runs very high, covering the meadow.

A shell placed at 6.30 P. M. last evening, and examined at 6.30

A. M. *this* morning, showed spat with a silpho growth one-fourth as wide as the fry shells. A favorite position for the spat is along the lines of growth under their protecting ledges. Other spat on yesterday's shells had no silpho growths.

A shell placed this morning at 9 o'cock shows at 5 P. M. the earliest formation of a silpho ring, like a hoarfrost fringe at the edge of the deutoconch valves, of a spat that has become attached in the meantime. Spat still younger have only a little bit of brownish cement at the edge of the left valve Some of the fry have cemented themselves fast in an almost upright position, and others are almost horizontal; the majority are in a midway position, tilted at an angle of about 45°.

The question of instituting a suitable and instructive experiment in shell planting engaged our attention. Several objects were held in view. First, how long does it take a fry to become fastened; second, how fast does it grow; third, how many spat can be collected in a given period; fourth, is there any preference for set times, comparing night and day, low and high water, ebb and flood tide, etc.; fifth, is there a climax on any particular day; is this due to special climatic conditions, or to the fact that the fry have reached a certain stage of development. We assumed that the latter of these two alternatives was the more reasonable.

The difficulties in conducting experiments that should plainly answer the above questions proved to be unexpectedly perplexing, yet a fair measure of success seemed attainable. Shells were placed to be taken away once, twice or three times a day; and shells were placed at morning, noon and night that were to be left for varying periods, and a series of shells was planted that should be observed once, twice or three times a day and returned. As regards the experiments already in progress, viz., the addition of new cultch daily to a given collection, to be examined at the close of the season, light would be thrown on the question, How long does it take cultch to become slimy so as to interfere with spat fixation? Unfortunately, the little snails crawling over the shells scraped off the marks, so that the dates were obliterated; but more uncertainty arose from other causes, such as the local variation in the amount of slime in different localities, on different

shells in the same locality, or on different areas of the same shell, not to mention the variation in the daily supply of mature fry.

These operations naturally became simplified as experience was gained. One very disturbing factor was the peculiar preference of the spat for certain shells, and avoidance of others. It is evident that shells are not the ideal cultch for a scientific or accurate quantitative experiment.

July 27th.—The six-hour period returnable shell has now 7 spat, three of which set this morning. The twelve-hour returnable shell has 7 spat, but most of them are now older than twelve hours. A replaceable shell, planted last evening, shows one spat this morning without silpho stage.

A shell planted yesterday at 9 A. M., and returned at 7 P. M., shows nothing at 9 A. M. to-day.

The shell planted July 25th, evening, upperdeck, and removed last night, has 6 spat. A similar one from lower deck has 3 spat.

The six-hour returnable shell examined at noon has 10 spat, two at least a day old, and two recently set.

The twenty-four hour returnable shows one newly set spat at noon.

A six-hour replaceable shell, planted this morning, has caught nothing by 2.30 P. M.; it had been on the crate during high water.

Tide at Laboratory Point, 13 inches at 10 A. M., s. g. 1074 at 72° Fahr., using mended hydrometer.

Tide, 5.5 inches, just turning to come in at Horace Point at 7 P. M., s. g. 1020 at 70° Fahr.

Filtration yields only 6 small fry.

July 28th.—A forty-eight hour shell, planted July 25th, has 16 spat. A similar one from lower deck has 19 spat. A shell planted July 22 had 30 spat.

The six-hour shells planted July 27th, at noon, and removed at night, shows nothing.

The twelve-hour replaceable, planted last night, and removed this morning, has no spat.

The twenty-four hour shell, planted July 26, and removed yesterday, has 3 spat, one just with an incipient silpho hinge, and two better developed.

One of the large fry shows a short tentacular foot just behind the velum. We are not sure this is an oyster fry, it may be a younger stage of the mactra-like larvæ found earlier this season.

At noon the six-hour shell planted this morning shows nothing.

A glass slide shows 5 spat of different ages.

Water from the crate filtered this evening contains 41 small and medium fry, 2 large ones and a host of snail fry.

Having found it impracticable to work the returnable series so as to get accurate results, this series was abandoned.

The routine and details of working the other three series will hereafter not be fully repeated in this journal, but will be shown in the Table of "Spatting Observations," and only specially interesting results will be noticed.

The six-hour shell this afternoon held one spat newly cemented; the twelve-hour shell held one newly cemented spat, and one with first fringe of the silpho stage. The twenty-four hour shell, planted yesterday evening, had 2 newly cemented spat. Shells planted July 25th show 26 to 28 spat, mostly newly attached.

Tide at Laboratory Point still ebbing at 7 P. M., s. g. 1014 at 76° Fahr.

July 29th.—A "southwester" raged this afternoon, but cleared up with calm by evening. Water from the crate yielded 23 medium fry, and a shell planted this morning yields 2 newly cemented spat by noon; while one planted at noon and taken at evening time yields 6 spat; another planted all day yields 12 spat, whereas the twenty-four hour shell yields only 6 spat, and the forty-eight hour shell only 5 spat. On the other hand, a shell planted four days ago (July 25) has 44 spat of two sizes, one set about four days old, the other recent. Another shell of similar age, planted on the lower deck of the crate, yields 23 spat on the smooth side, and 193 spat on the ridged side. It almost looks as though the storm had caused a hastening in spatting.

July 30th.—A twelve-hour shell placed last night has only 5 spat; a glass slip had only 1 spat, though it had been placed several days.

Water from near Laboratory Point yields only 11 fry, some of which contain an air bubble, indicating death. Water from

the crate yields 22 fry of all sizes; a pailful yielded 42 fry, the majority were larger than average.

A shell placed this morning caught 1 spat, one placed this afternoon caught none, one placed all day caught 4 spat. One shell, out all day and the previous night, caught none; but two shells placed July 25th had respectively 60 spat and 134 spat on the rough side, and 4 spat and 31 spat on the smooth side. Another five-day shell planted on the lower deck held 31 spat on the outer and 10 on the inner (smooth) side. But this shell was smaller than usual.

High water is at 1.00 P. M.

July 31st.—A twelve-hour shell, exposed during last night, has caught 6 spat by morning. A shell left out from this morning until noon, caught none; but a flat shell, out during the afternoon, caught 4 spat. A convex shell, out all day, caught only 2 spat. A flat shell, out last night and all day to-day, caught only 5 spat. A similar shell, planted two days, had but 9 spat; a three-day shell (left valve) had 11 spat on the smooth side and 37 on the rough side; while one planted July 25 held 29 spat on the smooth side and 55 on the ridged side.

A pailful of water from the creek near the laboratory yielded 12 small fry.

August 1st.—A pailful of water taken this morning from the middle of the lagoon, yielded 58 small fry and 2 large ones.

A shell out all of last night, caught 4 spat; one out this forenoon, caught none. Neither did one, out all the afternoon, catch any spat; nor another, out all day. But one, out all last night and to-day, had 18 spat; while three shells, out since July 25, held respectively 50, 26 and 71 spat. The last mentioned is a flat shell, which, by exception, caught 62 on its smooth side and only 9 on its rough outer side.

High water at 4 P. M.

August 2d.—All the shells from the cloth float were taken up. The shells in the compartment in which natural fry had been placed showed one or two spats per shell on those placed July 20th?, 21st, 21st, 22d?, 24th. Evidently these had received spat introduced before that date as well as some introduced later. The shells were quite slimy and probably did not catch

many spat later than the 25th, the time of climax of natural spatting. In the "natural" compartment, 5 shells held 8 spat; whereas in the "artificial" compartment 8 shells bore 23 spat. The artificial fry were planted July 19th, and were due to set about July 25th–30th. The following shells held spat: July 18th, 18th, 19th, 20th, 22d, 24th and 30th. Seven spat were found on the shell dated July 20th. The conditions for catching spat in this box were extremely unfavorable, so that no surprise need be expressed at the smallness of the total catch. We only note that the total set in the "artificial" compartment averaged more than twice as good as that of the "natural" compartment. We also brought up the floating box and the wire basket.

August 3d.—The water off Laboratory Point yields 50 medium fry. The shells brought up last night from the crate tell the usual story, as shown in the table. The ones planted July 25th are now eight days old, and hold 55 spat, while those planted on the 29th and 30th have but from 17 to 19 spat. The more recent shells have few or none. This story is also repeated with the shells brought up from the crate to-day.

August 4th.—The shells in the floating box are quite dirty, and only half of them have spat affixed, but the total number of spat in the "artificial compartment is more than twice that of the "natural" compartment.

The shells of the wire basket hold spat as follows: July 20th and 21st respectively, 52 and 55 spat; July 22d and 23d respectively, 27 and 43 spat; July 24th and 25th respectively, 70 and 78 spat; July 26th and 27th respectively, 11 and 6 spat; July 27th and 28th respectively, 48 and 13 spat; July 29th and 30th respectively, 13 and 3 spat. This record from Horace Point agrees, in relative distribution, remarkably closely with the distribution at the crate.

Tide is ebbing at noon.

August 5th.—The shells taken from the crate last night show no spat on any, except those planted July 25th and 30th, which respectively have 54 and 8 spat. We brought up the deep wooden box and shells. This held shells that were very dirty, but they lay in deeper water and received a good "set."

Tide at 11 A. M. is 1.5 inches, and water in lagoon is 1.010 specific gravity at 76° F.

August 6th.—Examined the shells from the deep wooden box. The total number of spat in the compartment receiving natural spat was 38, the largest number on one shell being 7 spat. The total number of spat on the shells in the artificial compartment was 171 spat; the largest number on a single shell being 42 spat; another shell had 26 spat, and another 17 spat. Several shells held 6 or 7 spat, and the general run was 2 or 3 spat per shell, as against 1 spat in the control compartment.

This is certainly quite a striking and encouraging experiment, and leads the way to a repetition of this work under more favorable conditions.

Tide at 3:30 P. M. is 0 and flowing in.

August 7th.—A bowlful of water from the crate yields 15 medium fry. The shells left on the crate since July 25 have 25 spat, while those planted August 4th and 5th have only 1 or 2 spat.

August 8th.—Shells examined this morning, that had been planted August 4th and 6th, average 6 or 7 spat each, while those planted July 25th were so well covered they were not counted.

August 9th.—Stormy weather. We left for New Brunswick for a few days, leaving P. C. Cameron in charge of the laboratory; observations on tides and temperatures were made daily, and shells placed daily on the crate. These were examined on the 15th. See weather and water conditions.

August 14th.—Water at the crate yields 46 small and medium fry, and 2 large ones.

August 15th.—Shells placed August 7th and 8th have nine spat each, those placed on the 9th and 10th have 1 spat each; August 11th, caught 4 spat, but none caught August 12th to the 14th.

New shells were placed and were examined August 22d, when it was seen that only 1 or 2 spat had caught. It seems remarkable, that with the absolutely large number of natural fry in the water, so few of them grow to the spatting stage.

On August 20th, 54 fry were obtained at one filtration, and on the 25th 19 fry.

A considerable part of our time was now occupied in inspection and direction of the work of getting the new boat ready for launching.

August 23d.—The new boat was finally launched this evening, but it became necessary to shift her gasoline tank from the stern to the bow to get sufficient flow to allow of operating her engines.

August 24th.—A very heavy rain fell during last night; the tide is also extra high. The new boat had her trial trip to-day, and the engines seemed to work to perfection.

August 25th.—Filtration of water, yields 19 small fry. Getting ready to go to Tuckerton by water.

August 26th.—Shells planted August 19th, 20th and 22d show from 1 to 3 spat apiece.

August 28th—Sailed to Tuckerton successfully; considerable delay was caused by accumulations of floating eel grass in the propellers.

September 9th.—Returned to Barnegat.

September 10th.—Put boat in storage in Perrine's yard for the season, and gave orders for overhauling, repairs and alterations. These had been suggested by the behavior of the boat under different conditions. She needed more ballast, larger propellers, alterations in the gasoline feed pipe, etc.

SECTION II. DEVELOPMENT OF SPAWN (TABLE I) SEE PLATE I.

Lot.	Date.	Locality.	Males.	Females.	Maturity.	Remarks.
I	June 9	Headleys, ...	......	......	Begin, ...	Natives. Spawn incipient.
II	" 9	"	......	......	Begin, ...	Hog Islands. Spawn slightly developed.
III	" 9	"	1	2	Near, ...	Much spawn.
IV	" 10	H. float, ...	......	......	Begin, ...	Spawn in 10%. Residue put at Laboratory Point.
V	" 10	Cat. Id., ...	2	3	Near, ...	1 m., 1 f., very good. Residue put at Laboratory Point.
VI	" 15	"	2	4	Begin, ...	Most not ripe. Residue at Laboratory Point.
VII	" 19	"	4	4	Near, ...	Fine granules.
VIII	" 21	"	2	6	Near, ...	Small O. riper than large.
IX	" 22	"	3	6	Almost, ...	
Xa	" 24	"	1	2	Part spawned,	Coarse granules.
Xb	" 24	"	3	7	Part spawned,	
Xc	" 24	"	1	1	Near, ...	Sticky, smooth, white.
XI	" 25	Upper lagoon,...	5	5	Part spawned,	
XII	" 27	Lab. Pt., ...	1	2	Spawning, ...	One ripe, one part spawned.
XIII	" 29	Cat. Id., ...	2	3	Ripe, ...	Well filled.
XIV	July 1	Lagoon, ...	?	6	Spawning, ...	Most have begun spawning.
XV	" 3	Cat. Id., ...	12	12	Part spawned,	Small ones spawning.
XVI	" 5	Crate, ...	Many	1	Spawned, ...	Most of 2 doz. through sp'n'g.
XVII	" 6	Lab. Pt., ...	3	3	Ripe, ...	
XVIII	" 6	Cat. Id., ...	?	?	Spawned, ...	Spawn in small, not in large.
XIX	" 10	Bay, ...	2	1	Almost, ...	Seven opened.
XX	" 13	Bay, ...	4	4	Ripe, ...	Garvey just landed.
XXI	" 14	Lab. Pt., ...	?	?	Spawned, ...	
XXII	" 15	Bay, ...	?	?	Ripe, ...	Garvey just landed.
XXIII	" 18	Bay, ...	4	3	Almost, ...	Males are ripe.

SECTION 12. BREEDING EXPERIMENTS. (TABLE II.) SEE PLATE I.

Lot.	Date.	Hour.	Development.	Remarks on Manipulation, etc.
III	June 9	5:00 P. M.	?	Washed once.
V	" 10	3:30 P. M.	Poor.	Washed eggs 15 m. Sperms infused 15 m.
VI	" 15	Noon.	Mantle.	Decomposed, flooded on float.
VII*	" 19	9:30 A. M.	Shell.	
VIII	" 21	10:30 A. M.	Poor.	Opened on grounds, fertilized at lab.
IX	" 22	9:30 A. M.	?	Infused as opened at the grounds.
X1	" 24	3:20 P. M.	?	† Xa, m and f.
X2	" 24	3:20 P. M.	?	† Xa with sperms of Xc.
X3	" 24	3:20 P. M.	?	† Xc with sperms of Xa.
X4	" 24	3:20 P. M.	?	† Xc, m and f.
XI	" 25	11:40 A. M.	Poor.	Infused 10 m. Opened at Laboratory.
XII	" 27	10:00 A. M.	Poor.	Infused 20 m. Lab. Pt. O.
XIII	" 29	10:00 A. M.	Poor.	Infused 30 m. Cat Id. O.
XIV	July 1	10:30 A. M.	Poor.	Infused 15-30 m. Fert. at 3d and 4th washings.
XV	" 3	1:00 P. M.	?	Infused 15 m. Fert. as opened.
XVI*	" 5	5:30 P. M.	Shell.	Infused. Fert. in boat at crate; planted in 3 boxes.
XVII	" 6	9:15 A. M.	Poor.	Infused 15 m. Triple fert. at 5 m. intervals.
XIX*	" 10	10:50 A. M.	Shell.	Infused 10 m. Triple fert. at 5 m. intervals. Planted in 3 boxes.
XX	" 13	1:00 P. M.	Shell.	Bay O. Died in early shell; planted in 3 boxes.
XXI	" 14	1:30 P. M.	Shell.	Lab. Pt. O. Died in early shell; discar'd.
XXIII	" 18	10:00 A. M.	Shell.	Infused 30-40 m.; results not excellent; planted in 3 boxes.

* Only reliable ones.

† Used filtered water from Horace Point. Lost most at separation.

SECTION 13. SPATTING OBSERVATIONS (TABLE III). SEE PLATE I.

DATES.	6 h.	12 h.	1 d.	2 d.	3 d.	4 d.	5 d.	6 d.	7 d.	8 d.	9 d.	10 d.	11 d.	12 d.	13 d.	14 d.	Aver.
July 20,												*				52	52
" 21,					11						*				55		33
" 22,				16 25				30		*				27			24
" 23,	a. 1	d. 2	1 20?						*				43				13
" 24,								*				70					70
" 25,		n. 4	t. 6 b. 3		t. 26 b. 28	44 216	*64 165 41	84	50 26 71	55*	42 78	54			25	8	57
" 26,			3			*				11							7
" 27,	a. 0 p. 0	n. 1 n. 0	2	5	*				6								2
" 28,	a. 0 p. 1	d. 2 n. 1		*	48			48									17
" 29,	a. 2 p. 6	d. 12 n. 5	*6 0	9		19	18										8
* " 30,	a. 1 p. 0	d. 4 n. 6	6 5		17	8	8										5
" 31,	a. 0 p. 4	d. 2 n. 4	18														6
August 1,	a. 0 p. 0	d. 0 n. 0	2	1	1												5
" 2,	a. 0 p. 0	d. 0 n. 2	0	0	2												5
" 3,	a. 0 p. 0	d. 0 n. 0	0														0
" 4,		d. 0 n. 0	0		2	6 7											2
" 5,		d. 0 n. 0		1													⅓
" 6,				7													7
Total average,..	1	2	5	8	17	49	58	54	38	33	60	62	43	27	40	50?	......
Daily average,..	8	4	3	4	6	12	12	9	5	4	7	6	4	2	3	4	......

a, Forenoon; p, afternoon; d, day; n, night; t, top deck; b, lower deck; h, hour.
Heavy-face type indicates highest numbers; note how they parallel the stars (*), which indicate the occurrence of July 30th.

SECTION 14. FILTRATION STUDIES (TABLE IV). SEE PLATE I.

Date.	Hour.	Locality.	O. fry, small.	O. fry, large.	Tide.	Remarks.
June 13,	8 p. m.,	Cat Id.,				No fry seen.
14,	10 a. m.,	Lab. Pt.,	?		High.	Two small bivalves.
15,	Noon,	Cat Id.,	?	2	¾ Fl.	Doubtfully oyster fry.
19,	7 p. m.,				Ebb.	No fry seen.
20,	8 a. m.,	Cat Id.,			"	" " "
"	7:30 p. m.,	" "			High.	" " "
21,	9 a. m.,	" "	?		4	Two bivalves doubtful.
"	Noon,	" "		1		Clam-like bivalve.
22,	10:30 a. m.,	" "				None seen.
23,	11:30 a. m.,	Shad Pt.,				" "
"	8 p. m.,	Cat Id.,				None seen; many annelid larvæ.
"	7 p. m.,	Lab Pt.,			High.	None seen.
24,	Noon,	Horace Pt.,			Half-Ebb.	" "
25,	11:30 a. m.,	Sans Souci,	8	1		Many small veligers.
"	2:30 p. m.,	Cat Id.,	4	2		
"	7 p. m.,	" "	2	1	High.	
26,	9 a. m.,	Shad Pt.,			"	Top water, many crustacea larvæ.
"	" "	" "	10	2		Sediment from bottom of pail.
"	1 p. m.,	Sans Souci,	1			Sediment interferes with count.
"	4 p. m.,	Cat Id.,	4	2		
"	5 p. m.,	Lab. Pt.,	4	2		Bottom water.
"	6 p. m.,	" "				Bottom water; none seen.
27,	Noon,	" "	2	1		Many snail larvæ.
"	"	Cat Id.,	1			
28,	10 a. m.,	Sans Souci,	2			
"	Noon,	Lab. Pt.,	1	2	High.	Surface, waves.
"	1:30 p. m.,	Shad Pt.,	2		8 in.	
"	4:30 p. m.,	Lab. Pt.,			5 in.	None seen; low water.
29,	10 a. m.,	Horace Pt.,	?			Much sediment, eggs; no fry seen.
"	Noon,	Lab. Pt.,			13	High water, no fry seen.
30,	"	" "			12	No fry, only small larvæ.
"	"	Cat Id.,		1		Sediment interferes with count.
"	7:30 p. m.,	" "		7		Found in sediment.
July 1,	10:30 a. m.,	" "		2		
2,	1 p. m.,	Horace Pt.,			Low.	None seen.
"	3 p. m.,	Lab. Pt.,		3		Possibly segmenting O. eggs in water.
3,	10 a. m.,	Cat Id.,		1		
"	11:30,	" "		4		None in top water of pail.
4,	Noon,	Horace Pt.,			2 in.	
"	"	Cat Id.,		3		

FILTRATION STUDIES (TABLE IV, *Continued*).

DATE.	Hour.	Locality.	O. fry, small.	O. fry, large.	Tide.	Remarks.
July 4	7:30 p. m.	Cat. Id.	10	1		Mactra-like veliger and O. eggs.
5	9 a. m.	Lab. Pt.	40		2.5	Half pailful.
"	1 p. m.	" "	18		1	Stiff wind, much debris.
"	3 p. m.	" "			2	None seen.
"	5 p. m.	" "	1			Pailful, much sediment.
6	9:30 a. m.	" "	13			Half pailful; several O. eggs.
"	10:30	Cat Id.	7			Lee shore.
"	5 p. m.	Conklin Id.	31			5 from top dipperful. 26 from bottom dipperful. Did not wash filter fold.
7	7 a. m.	Lab. Pt.	32			Top water, top of pail and debris.
"	" "	Lagoon	11			Dishful, top half dipper and bottom.
"	10 a. m.	Lab. Pt.	14			Surface rough, bottom two dippers.
"	11:30	" "	40			Filtered all; much debris.
"	4 p. m.	Cat Id.	3			One tumblerful.
"	8 p. m.	Lagoon	47			Fold not washed; little debris.
"	" "	Upper lagoon	105			Bowlful from calm surface.
"	" "	Lab. Pt.	25			Bowlful from bottom residue only.
"	" "	Lagoon & Pt.	238			Washed filters of previous three.
8	6 a. m.	Upper lagoon	25		4.5	Fold not washed; none except bottom.
"	" "	Lab. Pt.	45			Bowlful, residue.
"	10 a. m.	" "	63			Calm, fold washed.
"	6 p. m.	Upper lagoon	18			Debris only; fold not washed.
9	6 a. m.	Horace Pt.	55			Fold not washed.
"	9:30 a. m.	Lab. Pt.	11			Fold not washed; not skimmed.
"			62	1		Three filters washed.
"	10 a. m.	Lab. Pt.	25			Fold not washed. Top.
"	3 p. m.	" "	21		Low.	Fold not washed. Skimmed, only bottom filtered.
"	8:30 p. m.	" "	?		High.	Fold not washed. Skimmed, filtered residue.

FILTRATION STUDIES (TABLE IV, *Continued*).

DATE.	Hour.	Locality.	O. fry, small.	O. fry, large.	Tide.	Remarks.
July 10, ...	7 a. m., ...	Upper lagoon, ...	358	?	4.5	Calm, skimmed; fold washed later.
"	9:15, ...	Lab. Pt., ...	66	?	6.5	Calm, fold washed next day.
"	10 a. m., ...	Horace Pt., ...	90	?	....	Fold washed next day.
"	2 p. m., ...	Cat Id., ...	24	......	....	Water rough.
11, ...	7 a. m., ...	Lab. Pt., ...	24	6	....	Skimmed; fold washed later.
12, ...	9 a. m., ...	Horace Pt., ...	4	......	....	Much sediment; high wind.
"	1 p. m., ...	Lab. Pt., ...	6	......	....	
"	7 p. m., ...	Lagoon, ...	5	2	....	Skimmed various parts after wind died down.
"	" " ...	Lab. Pt., ...	1	......	....	
13, ...	8 a. m., ...	Upper lagoon, ...	....	3	5	
"	10 a. m., ...	" " ...	6	3	....	
"	Noon, ...	Horace Pt., ...	5	......	High.	
14, ...	3:30 p. m., ...	" "	....	13	Ebb.	
16, ...	9 a. m., ...	Upper lagoon, ...	2	1	....	
"	11 a. m., ...	Horace Pt., ...	2	......	Flow.	
17, ...	3 p. m., ...	" "	1	1	....	
18, ...	8:30 a. m., ...	" "	29	......	2	
"	7:30 p. m., ...	Upper lagoon, ...	10	1	....	Much debris from box.
19, ...	6 a. m., ...	" "	12	2	....	
"	10:30 a. m., ...	Sans Souci, ...	15	......	....	Sediment abundant.
"	11 a. m., ...	Upper lagoon, ...	16	......	....	
"	5 p. m., ...	Horace Pt., ...	19	1	....	
"	7 p. m., ...	Cat Id., ...	101	?	4	
20, ...	6 a. m., ...	Up. Creek, ...	16	......	5	
"	7 a. m., ...	Lagoon, ...	31	......	4	
"	4:30 p. m., ...	Horace Pt., ...	28	......	....	
21, ...	2 p. m., ...	" "	14	......	Low.	
"	7:30 p. m., ...	Upper lagoon, ...	49	Many	....	
22, ...	6 a. m., ...	" "	28	"	8	
"	8 a. m., ...	" "	7	......	7.5	
"	9 a. m., ...	" "	6	......	6.5	
"	10 a. m., ...	Cat Id., ...	12	Few	....	Dishful.
"	1 p. m., ...	Horace Pt., ...	4	3	....	
23, ...	8 p. m., ...	Upper lagoon, ...	1	9	....	Calm.
24, ...	9:30 a. m., ...	Cat Id., ...	22	......	....	At crate.
"	11:30, ...	Lab. Pt., ...	246	1	....	Out in creek, residue.
25, ...	6 a. m., ...	" "	14	......	10.5	" " "
"	8:30 a. m., ...	" "	7	......	13.	" " "
"	9:30, ...	Cat Id., ...	77	......	14.5	At crate.
"	11:30 a. m., ...	Lab. Pt., ...	3	......	12.	Bowlful.
"	3 p. m., ...	Upper lagoon, ...	10	......	7	Fold not washed.
"	6 p. m., ...	Cat Id., ...	14	......	10.5	At crate, filter washed later.
"	" " ...	Upper lagoon, ...	5	......	....	Bowlful, filter washed later.

FILTRATION STUDIES (TABLE IV, *Continued*).

DATE.	Hour.	Locality.	O. fry, small.	O. fry, large.	Tide.	Remarks.
July 25,	6 p. m.,		78			Filter of last three lots washed.
27,	7 p. m.,	Horace Pt.,	6		5.5	Much debris.
28,	7 p. m.,	Cat Id.,	14	2	4.5	At crate, ebb; many snails.
29,	7 p. m.	" "	23	Med.		Calm after storm, at crate.
30,	11:30 a. m.,	Upper lagoon,	11		10.5	Some with gas bubble.
"	1:30 p. m.,	Cat Id.,	22	Some		At crate.
31,	7:30 a. m.,	Upper lagoon,	24	"		
Aug. 1,	8 a. m.,	Lab. Pt.,	12		6.5	In creek.
2,	7:30 a. m.,	Upper lagoon,	3			
"	7:30 p. m.,	Cat Id.,	12			At crate.
3,	7:30 a. m.,	Upper lagoon,	50		6.5	
4,	7 p. m.,	" "	6		6.5	Bowlful.
"	" "	Cat Id.,	4			Bowlful at crate.
5,	8 a. m.,	Upper lagoon,	....		3	Dishful, none seen.
7,	9 a. m.,	Lab. Pt.,	4			Bowlful.
"	" "	Cat Id.,	15	Med.		Bowlful at crate.
14,	Noon,	Cat Id.,	46	2		At crate.
20,	10 a. m.,	" "	54			" "
25,	6 p. m.,	" "	19			" "

SECTION 15. WATER CONDITIONS (TABLE V).

DATE.	Hour.	Tide height.	Locality.	Temperature.	Salinity.	Miscellaneous.
June 7,	6:00 P. M.	High.	Laboratory Pt.,	68°	1006	
" 8,	1:00 P. M.	Low.	Laboratory Pt.,	62°	1004	Calm.
" 9,	P. M.	Half.	Headley Cr.,	69°	1009	Flood.
" 10,	11:00 A. M.	Eighth.	Laboratory Pt.,	65°	1010	Ebb.
" 10,	2:00 P. M.	....	Horace Point,	70°	1010	Ebb.
" 10,	2:30 P. M.	....	Cat Id.,	......	1008	
" 10,	8:00 P. M.	....	Laboratory Pt.,	......	1006	Ebb.
" 11,	6:00 A. M.	¾	Laboratory Pt.,	62°	1006	Flood.
" 18,	8:00 P. M.	Low.	Laboratory Pt.,	65°	1002	
			Cat Id.,	65°	1008	
" 14,	10:00 A. M.	High.	Laboratory Pt.,	60°	1006	
" 15,	10:00 A. M.	7 in.	....	......	......	Tide guage set up.
" 15,	Noon.	9 in.	Cat Id.,	64°	1005	High water at noon.

SECTION 15. WATER CONDITIONS (TABLE V, *Continued*).

DATE.	Hour.	Tide height.	Locality.	Temperature.	Salinity.	Miscellaneous.
June 18,.....	7:00 P. M.	0	Laboratory Pt.,	70°	1002	
" 19,.....	9:30	—2	Cat Id.,........	70°	1005	
" 19,.....	9:30	....	Horace Pt.,....	......	1006	
" 19,.....	9:30	....	Laboratory Pt.,	......	1002	
" 19,.....	7:00 P. M.	....	Laboratory Pt.,	70°	1003	Ebb.
" 20,.....	8:00 A. M.	2	Cat Id.,........	70°	1006	Ebb.
" 20,.....	7:30 P. M.	High.	Cat Id.,........	......	1008	High water 7 P. M.
" 21,.....	9:00 A. M.	4	Cat Id.,........	72°	1006	
" 21,.....	9:00 A. M.	4	Laboratory Pt.,	74°	1000	
" 21,.....	3:00 P. M.	2	Cat Id.,........	82°	1004	Flow.
" 22,.....	8:00 A. M.	4	Laboratory Pt.,.	74°	1003	
" 22,.....	9:30 A. M.	....	Horace Pt.,....	72°	1006	
" 22,.....	10:30 A. M.	....	Cat Id.,........	......	1004	
" 22,.....	10:45 A. M.	2	Laboratory Pt.,	......	1000	
" 22,.....	1:00 P. M.	—1	....	......	......	Low water at noon.
" 22,.....	7:00 P. M.	6.5	....	84°	1004	
" 23,.....	9:00 A. M.	4.5	....	80°	......	Ebb.
" 23,.....	10:00 A. M.	4	....	......	......	
" 23,.....	11:30 A. M.	2.5	Laboratory Pt.,	80°	1004	
" 23,.....	11:30 A. M.	....	Lagoon, ...	78°	1006	
" 23,.....	....	....	Shad Pt.,......	......	1006	
" 23,.....	3:00 P. M.	1	Laboratory Pt.,	84°	1003	
" 23,.....	3:00 P. M.	....	Cat Id.,........	82°	1005	
" 23,.....	7:00 P. M.	7	Laboratory Pt.,	80°	1006	
" 24,.....	Noon.	4	Laboratory Pt.,	78°	1001	
" 24,.....	Noon.	....	Cat Id.,........	78°	1006	Ebb.
" 24,.....	Noon.	Half.	Horace Pt.,....	78°	1006	
" 25,.....	9:00 A. M.	9 in.	Laboratory Pt.,	80°	1001	Moon full.
" 25,.....	9:00 A. M.	....	Cat Id.,........	78°	1004	
" 25,.....	2:30 P. M.	2	Laboratory Pt.,	86°	1000	Ebb.
" 25,.....	2:30 P. M.	....	Cat Id.,........	84°	1006	
" 25,.....	7:00 P. M.	6	....	......	......	
" 25,.....	10:00, P. M.	13	....	......	......	High water.
" 26,.....	9:00 A. M.	....	Horace Pt.,....	......	1010	High water.
" 26,.....	9:00 A. M.	11	Laboratory Pt.,	......	1004	
" 26,.....	2:00 P. M.	5.3	....	......	......	
" 26,.....	7:30 P. M.	10	Laboratory Pt.,	......	1006	
" 26,.....	7:30 P. M.	....	Cat Id.,........	......	1006	
" 26,.....	9:00 P. M.	14	....	......	......	
" 26,.....	10:30 P. M.	16	....	......	......	Showers.
" 27,.....	9:00 A. M.	12	Laboratory Pt.,	......	1008	
" 27,.....	Noon.	10.5	Laboratory Pt.,	75°	......	
" 28,.....	8:30 A. M.	7 in.	....	......	......	
" 28,.....	10:00 A. M.	10 in.	Horace Pt.,....	70°	......	
" 28,.....	....	....	Laboratory Pt.,	74°	1003	
" 28,.....	....	....	Cat Id.,........	......	1006	
" 28,.....	....	....	Shad Pt.,......	......	1008	High water at 11:30 A. M.
" 28,.....	1:30 P. M.	8 in.	....	......	......	
" 28,.....	4:30 P. M.	5 in.	....	......	......	
" 28,.....	6:00 P. M.	3 in.	....	......	......	
" 28,.....	7:30 P. M.	3 in.	....	......	......	

SECTION 15. WATER CONDITIONS (TABLE V, *Continued*).

DATE.	Hour.	Tide height.	Locality.	Temperature.	Salinity.	Miscellaneous.
June 29,	8:00 A. M.	7.5				
" 29,	9:00 A. M.		Horace Pt.,		1006	
" 29,	9:00 A. M.		Cat Id.,		1008	
" 29,	9:00 A. M.		Laboratory Pt.,	70°	1004	
" 20,	10:00 A. M.	10.5				
" 29,	Noon.	11				
S " 30,	Noon.	12	Laboratory Pt.,	72°	1008	
" 30,	Noon.	12	Cat Id.,	72°	1007	
" 30,	7:30 P. M.	8.5				
July 1,	7:00 A. M.	7				Lowest at 9:30 A. M.
" 1,	Noon.	8	Cat Id.,	74°	1005	
" 1,			Laboratory Pt.,		1003	
" 1,			Horace Pt.,		1006	
" 1,	3:30 P. M.		Laboratory Pt.,	74°		
" 1,	7:30 P. M.	4.5				
" 2,	8:00 A. M.	5.5				
" 2,	10:30 A. M.	4.5	Laboratory Pt.,		1004	
" 2,	10:30 A. M.		Cat Id.,		1005	
" 2,	1:00 P. M.	7				
" 2,	4:00 P. M.	10				
" 3,	7:20 A. M.	7.5	Laboratory Pt.,		1005	
" 3,	7:20 A. M.		Cat Id.,		1007	
" 3,	9:45 A. M.	4.5				
" 3,	1:00 P. M.		Cat Id.,		1006	
" 3,	3:00 P. M.		Laboratory Pt.,	71°		
" 3,	7:00 P. M.	7				
" 4,	11:00 A. M.	3				
" 4,	1:00 P. M.	2	Laboratory Pt.,		1004	
" 4,			Cat Id.,		1006	
" 4,	7:30 P. M.	4.5	Laboratory Pt.,	78°	1005	
" 4,			Cat Id.,	76°	1005	
" 5,	9:00 A. M.	2.5	Laboratory Pt.,	78°	1004	
" 5,	1:00 P. M.	1				
" 5,	3:00 P. M.	2				
" 5,	5:00 P. M.		Cat Id.,	75°	1007	
" 6,	9:30 A. M.	2.5	Laboratory Pt.,	75°	1006	
" 6,	12:30 P. M.	1				Ebb.
" 6,	5:00 P. M.	1				Flow.
S " 7,	7:00 A. M.	7				
" 7,	10:00 A. M.	5				
" 7,	11:30 A. M.	3.5	Laboratory Pt.,	77°	1005	
" 7,	1:30 P. M.	2				
" 7,	4:00 P. M.	2				
" 7,	6:30 P. M.	6				
" 8,	5:30 A. M.	4.5				
" 8,	9:00 A. M.	7	Laboratory Pt.,	80°	1005	
" 8,	10:00 A. M.	6				
" 8,	6:00 P. M.	5	Laboratory Pt.,		1005	
" 9,	6:00 A. M.	4 in.				
" 9,	9:30 A. M.	6	Laboratory Pt.,	85°	1004	

SECTION 15. WATER CONDITIONS (TABLE V, *Continued*).

	Date.	Hour.	Tide height.	Locality.	Temperature.	Salinity.	Miscellaneous.
	July 9, ...	12:30 P. M.	2.5	....	......	......	
	" 9, ...	3:00 P. M.	1	....	......	......	
	" 9, ...	8:00 P. M.	High.	Laboratory Pt.,	76°	1006	Cooled surface.
	" 10, ...	7:00 A. M.	4.5	....	......	......	
	" 10, ...	9:15 A. M.	6.5	....	......	......	
	" 10, ...	Noon.	....	Bay, ...	79°	1008	
	" 10, ...	....	....	Horace Pt., ...	80°	1006	
	" 10, ...	....	....	Laboratory Pt.,	82°	1006	
	" 10, ...	3:00 P. M.	Low.	Laboratory Pt.,	84°	1002	
	" 11, ...	10:30 A. M.	7.5	....	......	......	
	" 12, ...	8:00 A. M.	8	....	......	......	
	" 12, ...	9:00 A. M.	....	Horace Pt., ...	77°	1007	
	" 12, ...	....	....	Laboratory Pt.,	82°	1005	
	" 12, ...	1:00 P. M.	5	....	......	......	
	" 13, ...	7:00 A. M.	4	....	......	......	
	" 13, ...	11:15 A. M.	6	....	......	......	High water.
S	" 14, ...	11:30 A. M.	5.5	....	......	......	
	" 14, ...	6:30 P. M.	1	....	......	......	
	" 16, ...	7:30 A. M.	3.5	....	......	......	
	" 16, ...	9:00 A. M.	8	....	......	......	Flow.
	" 16, ...	3:00 P. M.	....	Horace Pt., ...	80°	1007	
	" 16, ...	7:30 P. M.	1	....	......	......	
	" 17, ...	1:00 P. M.	2	....	......	......	
	" 17, ...	2:00 P. M.	3	....	......	......	
	" 17, ...	3:00 P. M.	....	Horace Pt., ...	85°	1007	
	" 17, ...	5:00 P. M.	1	....	......	......	
	" 18, ...	8:00 A. M.	2	....	......	......	Ebb.
	" 18, ...	10:30 A. M.	1	....	......	......	Ebb.
	" 18, ...	1:00 P. M.	3	Laboratory Pt.,	80°	......	Flow.
	" 18, ...	6:00 P. M.	4	....	......	......	
	" 18, ...	7:30 P. M.	4	Laboratory Pt.,	72°	1010	Stood all night in lab.
	" 19, ...	6:00 A. M.	4	Laboratory Pt.,	76°	1008	Surface.
	" 19, ...	9:00 A. M.	1	....	......	......	Low water.
	" 19, ...	3:00 P. M.	5	....	......	......	
	" 19, ...	5:00 P. M.	5	....	......	......	High water.
	" 19, ...	6:00 P. M.	4	....	......	......	
	" 19, ...	7:00 P. M.	4	....	......	......	
	" 20, ...	6:00 A. M.	5	Up creek, ...	75°	1009	
	" 20, ...	Noon.	1	Lagoon, ...	76°	1010	
	" 20, ...	5:00 P. M.	3	Horace Pt., ...	79°	1010	
S	" 21, ...	Noon.	2.5	....	......	......	
	" 21, ...	2:00 P. M.	4	Laboratory Pt.,	80°	1010	Bay water, 78°.
	" 21, ...	7:00 P. M.	10	....	......	......	
	" 22, ...	6:00 A. M.	8	....	......	......	Ebb.
	" 22, ...	3:00 P. M.	1	....	......	......	
	" 22, ...	7:00 P. M.	9	....	......	......	

SECTION 15. WATER CONDITIONS (TABLE V, *Concluded*).

DATE.	Hour.	Tide height.	DATE.	Hour.	Tide height.
July 23,......	7:30 A. M.	9.5	August 4,....	7:00 P. M.	6.5
" 23,......	10:30 A. M.	8	" 5,....	8:00 A. M.	3
" 23,......	7:30 P. M.	12.5	" 5,....	10:00 A. M.	1.5
" 24,......	8:00 A. M.	11.5	" 5,....	11:00 A. M.	1.5
" 24,......	9:00 A. M.	12	" 5,....	1:00 P. M.	1.5
" 24,......	2:00 P. M.	7	" 5,....	4:30 P. M.	1.5
" 24,......	5:00 P. M.	7	" 6,....	10:00 A. M.	1.5
" 24,......	7:30 P. M.	11	" 6,....	8:30 P. M.	0.0
" 25,......	6:00 A. M.	9.5	" 7,....	7:00 A. M.	3.5
" 25,......	10:00 A. M.	14.5	" 7,....	9:00 A. M.	4.5
" 25,......	4:30 P. M.	7	" 7,....	3:00 P. M.	2
" 25,......	6:00 P. M.	10.5	" 8,....	9:00 A. M.	5
" 26,......	7:00 A. M.	10	" 9,....	9:00 A. M.	3
" 26,......	11:00 A. M.	14	" 9,....	3:20 P. M.	6
" 27,......	8:00 A. M.	9	" 10,....	8:00 A. M.	9.5
" 27,......	10:00 A. M.	13	" 10,....	1:00 P. M.	6.5
" 27,......	2:00 P. M.	10.5	" 10,....	5:15 P. M.	2.3
" 27,......	7:00 P. M.	5.5	" 11,....	10:30 A. M.	9.5
" 28,......	7:00 A. M.	5.5	" 11,....	6:00 P. M.	2.3
" 28,......	7:00 P. M.	4.5	" 12,....	Noon.	9
" 29,......	6:00 A. M.	7	" 12,....	7:00 P. M.	2.3
" 29,......	Noon.	11	" 13,....	1:15 P. M.	9.5
" 29,......	4:00 P. M.	7.5	" 13,....	7:00 P. M.	2.3
" 30,......	8:00 A. M.	7	" 14,....	6:00 A. M.	4.5
" 30,......	2:30 P. M.	12.5	" 15,....	7:00 A. M.	1.0
" 31,......	7:30 A. M.	8	" 16,....	7:00 A. M.	1.0
" 31,......	2:30 P. M.	11	" 17,....	9:00 A. M.	0.5
August 1,....	10:00 A. M.	5	Ebb. s. g. 1000 at 72° Lab. Pt.		
" 1,....	2:00 P. M.	8	1006 at Cat Island.		
" 1,....	6:30 P. M.	9	August 18,....	9:00 A. M.	1.5
" 1,....	7:30 P. M.	8.5	" 19,....	7:30 A. M.	5
" 2,....	7:30 A. M.	7.5	" 20,....	10:00 A. M.	3
" 2,....	10:00 A. M.	5	" 21,....	9:00 P. M.	Over meadow.
" 2,....	6:00 P. M.	8	" 22,....	5:30 P. M.	7.5
" 2,....	7:30 P. M.	6.5	" 22,....	10:00 P. M.	13.5
" 3,....	7:00 A. M.	6.5	" 23,....	6:00 A. M.	9
" 3,....	2:30 P. M.	4	" 25,....	11:00 A. M.	17.5
" 3,....	7:00 P. M.	8	" 25,....	6:00 P. M.	9
" 4,....	7:00 A. M.	6	S. g. 1004 at Cat Island at 74°.		
" 4,....	Noon.	2	August 26,....	9:30 A. M.	12

SECTION 16. WEATHER CONDITIONS (TABLE VI).—SEE PLATE I.

	DATE.	Hour.	Air. Temp.	Wind.	Remarks.
	June 7,.....	6:00 P. M.	70°	....	Extra high tide.
	" 8,.....	1:00 P. M.	62°	Calm.	Stormy in morning.
	" 10,.....	11:00 A. M.	60°	....	
	" 11,.....	6:00 A. M.	52°	....	
	" 13,.....	3:00 P. M.	60°	....	
	" 14,.....	10:00 A. M.	60°	N. E.	Storm, extra high tide.
	" 15,.....	8:00 A. M.	64°	Calm.	Clear.
	" 15,.....	Noon.	70°	....	
	" 15,.....	2:30 P. M.	75°	....	
	" 18,.....	7:00 P. M.	70°	....	Extra low tide.
	" 19,.....	9:30 A. M.	70°	Strong S. E.	
	" 20,.....	1:00 P. M.	73°	Strong S. W.	
	" 21,.....	9:00 A. M.	74°	....	
	" 21,.....	3:00 P. M.	78°	....	
	" 22,.....	8:00 A. M.	70°	Calm.	Clear.
	" 22,.....	Noon.	80°	....	
	" 22,.....	7:00 P. M.	73°	....	
S	" 23,.....	9:00 A. M.	73°	....	Hazy.
	" 23,.....	Noon.	70°	S. E.	Storm at 7 P. M.
	" 24,.....	3:00 P. M.	72°	S.	
	" 25,.....	9:00 A. M.	80°	....	Moon full.
	" 26,.....	Noon.	80°	Strong S.	Showers evening and night.
	" 27,.....	8:00 A. M.	68°	....	
	" 27,.....	Noon.	72°	....	
	" 27,.....	9:00 P. M.	70°	....	
	" 28,.....	6:00 A. M.	63°	....	
	" 28,.....	10:00 A. M.	72°	S. E.	
	" 28,.....	P. M.	80°	....	
	" 29,.....	10:00 A. M.	70°	N. E.	Storm, severe at night.
	" 29,.....	9:00 P. M.	68°	....	
S	" 30,.....	11:00 A. M.	74°	Strong S. W.	Showers, followed by calm.
	July 1,.....	7:00 A. M.	67°	....	
	" 1,.....	Noon.	78°	S. W.	Calm morning.
	" 1,.....	3:30 P. M.	75°	....	
	" 2,.....	8:00 A. M.	72°	....	
	" 2,.....	Noon.	78°	....	
	" 2,.....	3:00 P. M.	84°	N. W.	Hot wave.
	" 3,.....	7:00 A. M.	65°	N. E.	Threatening morning.
	" 3,.....	11:00 A. M.	71°	....	
	" 3.....	3:00 P. M.	76°	E.	Night cool, 67°.
	" 4,.....	9:00 A. M.	70°	E.	
	" 4,.....	Noon.	72°	....	
	" 4,.....	7:30 P. M.	70°	....	Night cool.
	" 5,.....	9:00 A. M.	72°	Calm.	Becomes strong S. wind.
	" 6,.....	A. M.	....	S. W.	Becomes strong S. wind at 10 A. M.
S	" 7,.....	7:00 A. M.	72°	Calm.	Becomes strong S. wind at 10 A. M.
	" 7,.....	9:30 A. M.	75°	S.	Calm in evening after showers.
	" 8,.....	6:00 A. M.	73°	Calm.	
	" 8,.....	10:00 A. M.	81°	....	
	" 8,.....	6:00 P. M.	82°	....	
	" 8,.....	10:00 P. M.	78°	....	
	" 9,.....	6:00 A. M.	74°	Strong N. W.	

SECTION 16. WEATHER CONDITIONS (TABLE VI, *Continued*).

DATE.	Hour.	Air. Temp.	Wind.	Remarks.
July 9,.....	Noon.	82°	W.	
" 9,.....	3:00 P. M.	82°	....	
" 10,.....	6:00 A. M.	70°	Calm.	
" 10,.....	10:00 A. M.	78°	Gentle W.	
" 11,.....	7:00 A. M.	76°	W.	
" 11,.....	Noon.	85°	Strong S. W.	
" 11,.....	6:00 P. M.	90°	Strong N. W.	Wind storm, temp. drop to 80°.
" 12,.....	7:00 A. M.	72°	Strong S. W.	
" 12,.....	8:00 A. M.	80°	Strong S. W.	Calm in evening.
" 13,.....	7:00 A. M.	69°	Gentle N. W.	
S " 14,.....	11:30 A. M.	78°	S. E.	
" 15,.....	A. M.	71°	Strong N. E.	
" 16,.....	6:00 A. M.	74°	S. E.	
" 16,.....	3:00 P. M.	76°	S.-S. W.	
" 17,.....	Noon.	82°	Strong S.	
" 18,.....	8:00 A. M.	78°	W.	
" 18,.....	Noon.	82°	S.	
" 18,.....	4:30 P. M.	....	N. W.	Thunder showers, through night, calm.
" 19,.....	6:00 A. M.	74°	S. W.	Cloudy.
" 19,.....	9:00 A. M.	....	N.-N. E.	Showers.
" 19,.....	3:00 P. M.	79°	S. E.	
" 19,....	6:00 P. M.	75°	....	
" 20,.....	6:00 A. M.	70°	S. W.	Foggy.
" 20,.....	1:00 P. M.	76°	S.	Cloudy.
" 20,.....	3:00 P. M.	....	N.-N. E.	Thunder showers.
" 20,.....	4:00 P. M.	....	N. W.-W.	Rain.
" 20,.....	5:00 P. M.	74°	S.	
S " 21,.....	Noon.	78°	N. W.	
" 21,.....	3:00 P. M.	80°	....	
" 21,.....	7:00 P. M.	76°	Calm.	
" 21,.....	11:00 P. M.	67°	....	
" 22,.....	5:30 A. M.	64°	....	
" 22,.....	8:00 A. M.	73°	Gentle N. W.	
" 22,.....	10:00 A. M.	75°	N.	
" 22,.....	1:00 P. M.	78°	S. E.	
" 22,.....	7:00 P. M.	72°	W.	
" 23,.....	7:30 A. M.	78°	N. W.	Hot wave begins.
" 23,.....	10:30 A. M.	83°	Strong N. W.	Calm evening.
" 24,.....	8:00 A. M.	74°	N. E.	
" 24,.....	9:00 A. M.	76°	E.	
" 24,.....	8:00 P. M.	74°	S. E.	
" 25,.....	6:00 A. M.	74°	Calm.	
" 25,.....	7:00 A. M.	....	S. W.	Calms between changes of wind direction.
" 25,.....	8:30 A. M.	....	N. W.	
" 25,.....	10:00 A. M.	82°	S. E.-S.	
" 25,.....	2:30 P. M.	87°	S. W.	
" 25,.....	6:30 P. M.	84°	Calm.	
" 25,.....	10:00 P. M.	78°	Calm.	Rainy night. high tide.
" 26,.....	7:00 A. M.	78°	....	
" 26,.....	11:00 A. M.	....	Strong N. W.	

SECTION 16. WEATHER CONDITIONS (TABLE VI, *Continued*).

DATE.	Hour.	Air. Temp.	Wind.	Remarks.
July 26,.....	7:00 P. M.	80°	....	
" 26,.....	10:00 P. M.	77°	....	
" 27,.....	7:00 A. M.	62°	Strong N. W.	
" 27,.....	2:00 P. M.	76°	Fitful W.	
" 27,.....	4:00 P. M.	80°	....	
" 28,.....	7:00 A. M.	66°	Calm.	
" 28,.....	11:30 A. M.	....	N. W.-W.-S.W.	
" 28,.....	5:00 P. M.	80°	S.-W.	
" 28,.....	10:00 P. M.	68°	....	
" 29,.....	6:00 A. M.	70°	W.-S.-S. E.	Rainy.
" 29,.....	3:00 P. M.	....	Strong S. W.	Storm.
" 29,.....	4:00 P. M.	72°	Calm.	Clearing.
S " 30,.....	8:00 A.M .	70°	W.	Foggy.
" 30,.....	11:30 A. M.	78°	Calm.	
" 30,.....	Noon.	....	S. W.-S.	Fitful breezes.
" 31,.....	7:30 A. M.	71°	Gentle S. E.	Clear.
" 31,.....	2:30	76°	....	
August, 1,....	7:00 A. M.	68°	Calm.	Cloudy.
" 1,....	6:30	74°	....	
" 2,....	7:30	72°	E.	
" 2,....	Noon.	....	Strong S.	
" 2,....	6:00 P. M.	79°	Strong S.	
" 2,....	10:00 P. M.	74°	Strong S.	
" 3,....	7:30 A. M.	72°	N. W.	
" 3,....	2:30 P. M.	76°	W.	Rain at night.
S " 4,....	7:00 A. M.	64°	....	
" 4,....	5:00 P. M.	78°	....	
" 5,....	8:00 A. M.	70°	Calm.	
" 5,....	4:30 P. M.	74°	....	Rain at night.
" 6,....	10:00 A. M.	77°	....	Rain at night.
" 7,....	9:00 A. M.	78°	....	
" 8,....	Noon.	90°	....	Hot wave.
" 9,....	....	....	Strong E.	Rainy day.
" 10,....	8:00 A. M.	....	E.	Stormy.
S " 11,....	8:00 A. M.	....	E.	
" 12,....	10:00 A. M.	....	Strong S.	
" 12,....	11:00 P. M.	73°	....	
" 13,....	Noon.	82°	Strong W.	Strong N. W. all night.
" 14,....	6:00 A. M.	60°	Strong N. W.	
" 15,....	7:00 A. M.	60°	....	
" 16,....	7:00 A. M.	62°	....	Rainy night.
" 17,....	9:00 A. M.	72°	S. W.	Rainy night.
S " 18,....	9:00 A. M.	78°	N.	Cloudy.
" 19,....	7:30 A. M.	70°	Strong E.	Clear.
" 20,....	10:00 A. M.	76°	....	
" 21,....	9:00 P. M.	....	....	Warm, muggy day, showers, tide extra high.
" 22,....	5:30 A. M.	68°	....	
" 23,....	6:00 A. M.	64°	....	
" 23,....	Night.	....	Strong S. E.	Heavy rain.
" 24,....	3:00 P. M.	79°	....	Rainy morning.
S " 25,....	Noon.	76°	Strong N. W.	
" 26,....	9:30	70°	....	

SECTION 17. EXPLANATION OF PLATES I TO XIII.

PLATE I.

On this plate is represented graphically, by means of plotted "curves," the data of Tables I. to VI. While the data are in some respects fragmentary, yet their graphic presentation is sufficiently indicative to be of value.

The original aim of the observations contemplated their continuation only to the time oyster spat became visible to the naked eye. Expecting that this event would occur about July 10th, and that the new boat would be secured by that date, our plans had been laid quite differently from the course that we actually pursued. The boat was not ready until near the close of August, and much interruption arose in connection with superintending her construction. The spat were not visible until nearly the fourth week of July. Thus our data are full enough for plotting purposes, only up to the first days of August.

The temperature curve:

This is represented by the maximum readings of the thermometer from June 6th to August 9th. All excess above 70° Fahrenheit has been filled in solidly with black to show the succession of warm waves.

Wherever there was a deficiency in our record in Table VI. the observations published in the New Jersey monthly weather reports were used, taking the mean between Asbury Park and Atlantic City. It will be seen that no warm waves sufficient to influence spawning occurred until after June 15th, and that thenceforth they followed one another pretty regularly, and that the oysters matured quickly. The large black dots from June 24th to July 6th represent spawning observations. Spawning began in earnest about ten days after the commencement of warm weather, and reached a climax on the fourth warm wave.

The curve of oyster larvæ:

This curve is the broken or dotted line, and it will be noted that it starts at the same date as the spawning, and becomes suddenly very steep at the close of the spawning climax. The data

from Table IV. were used, taking the average of all the observations each day.

The remarkable drop in the cruve at July 12th indicates, partly that the fry had to a great extent died, but also that currents had swept them away, and probably other causes also account for this fall. The continued warm weather brought the early spawners a second time into maturity, and possibly also the oysters in the bay had now reached maturity. By July 24th we got a second climax of oyster larvæ. The curve here (with due allowance for tidal fluxations) runs high for a considerable distance, spawning is more steady and not so fluctuating a process.

The tidal curve:

This has been plotted from Table V. Only the maximum height reached each day has been plotted. The highest parts of the curve fall during the first spawning period, and during the second larval period. It does not appear that there is any definite relation of the tides (considered in this way) to the facts of spawning or spatting.

Spatting:

The semicircles with shaded peripheries represent spatting observations; the height of these symbols above the base line shows the relative abundance of the set. No general set was noticed until July 21st, at which time the oldest spat were about six days old.

PLATE II.

Figures 1 to 15, newly attached spat. The magnification is indicated on the plate thus: x35, x37, x47, x50, etc., which means thirty-five times, or thirty-five diameters, thirty-seven diameters, and so on respectively.

Figures 1 to 9 show spat on shells that were exposed six hours; figure 10, eight hours; figures 11 to 15, twelve hours.

In the first four figures the spat have just begun the attachment; towards the close of the six hour period the young oyster has deposited a brownish cement (*c*) under and around the left valve, which extends onto the cultch for a varying distance, and is even placed back of the huge area, or *umbo*. Upon this brown-

ish cement there is deposited successive layers in ever enlarging circles, of a shell-like whiter substance called the silpho shell to distinguish it from the original larval shell. The latter is shaped almost like that of a clam except that the left *umbo* is more prominent than is the umbo of the right valve.

The main growth is in the direction in which the shell opens, the hinge being at the umbones. The umbones are marked by the letter *u* and represent the original first shell or protoconch that was acquired the first day of spawning. The rest of the larval shell has been acquired by additions showing concentric "lines of growth" like those of a clam's shell, until the shell at the time of "setting" is at least four times wider than when it started, and that means an increase in bulk of at least sixty-four times. The actual size of the larval shell at times of setting is one-fiftieth of an inch in length.

The designating letters indicate as follows: L, left valve; R, right valve; l, liver, *u*, umbo; *c*, brown cement; s, silpho shell.

Note that at the close of the first twelve hours a strut-like straight-edged growth, as seen in figures 14 and 15, extends from the hinge forward down to the cultch and involves both valves. A similar growth will also be made at the other end of the hinge.

Note also that the figures have all been reversed by the compound microscope, so that whereas S is placed in front of the spat, and that the right valve (R) is uppermost, nevertheless the figures appear as if the spat rested on the right side.

Note further that the spat takes all sorts of positions, from resting directly on the side, as in Figure 10, to standing almost on edge, as in Figure 4, the favorite position is at an angle of 45°. Also, the position on the cultch is diverse, but for the remaining plates we have drawn the figures with the hinge end toward the top of the page.

TABLE III.

The meanings of the designating letters are given under the explanation of Plate II. This plate shows spat as seen on cultch that has been in the water from one to two days. Figure 27 shows the state of growth during the early part of the second day.

PLATE IV.

General description under Plate II. applies here. Figures 28 to 32 show the growth of spat during the second day. Figures 32 to 35 during the third day, Figures 36 and 37 during the fourth day, Figures 38 and 39 during the fifth day. Note, that the silpho shell *s* is added in concentric additions, and that at the hinge area h, the cement *c* finally becomes covered by silpho additions.

PLATE V.

Growth of spat from the fifth to the tenth day after "setting." During this period the edge of the silpho shell becomes crenulate, and a prominent ridge is developed down the center from the point occupied by the larvæ shell.

Figure 43, the largest spat found July 21st, on a shell planted July 14th. By comparison with Figure 42, we conclude that this set on the same day as the shell was planted, or at least as early as July 15th.

Figure 45, the average size of the largest spat on shells picked up at Shad Point July 31st. Some picked up July 21st have spat like Figure 43; some taken July 25th have spat like Figure 44. The natural set from Clam Island, taken July 31st, and photographed at *c* Plate VIII. is about the same size as that drawn in Figure 45. The actual size of these is over three millimeters or one-eighth of an inch. This may be considered an average size for spat two weeks old.

PLATE VI.

Photographs of shells placed in the crate and bearing young spat. To enable the observer to see the young spat, and not confuse them with other small black dots and holes, a circle or ring was drawn around each individual spat.

A. Inside view of a shell placed July 28th and removed July 31st. It held 48 spat, mostly on the back, or hidden side, in the picture.

B. Outside view of a shell placed July 25th and removed July 27th.

C. Inside and outside views respectively of two shells planted July 25th and removed July 28th.

PLATE VII.

A. A shell planted in the crate July 25th and removed July 29th. During the four days 216 spat attached themselves to it.

B. A smiliar shell removed next day; it caught 165 spat. The inside surface shown in the picture caught relatively few as compared with the outside surface, as seen in A

PLATE VIII.

A. Shells planted early in the season at Shad Point and removed July 21st. Only a few of the spat have been "ringed." They "set" about July 15th, and have grown rapidly.

B. A shell from Shad Point, taken July 25th.

C. A shell from Clam Island, taken July 30th. Holds spat two weeks old.

D. A shell from Cat Islands, planted early in the season and taken August 5th. Notice the considerable growth. It is evident that all these spat "set" at about the same date, at the first climax of spatting, which with due allowance for rapid growth could not have been later than July 18th or 19th. They are probably twenty days old.

PLATE IX.

Natural spat or seed oysters from Barnegat, taken September 10th, 1907. About forty-five to fifty days after setting.

PLATE X.

A. B. Oyster seed "set" in 1906 at Barnegat, taken June, 1907. Many of the little oysters have died.

C. D. Young oyster spawners; natural seed oyster clusters of the lagoon at Barnegat, supposed to have set in 1905 and taken nearly two years later. Such oysters as these, furnished spawn for a number of the propagation experiments.

PLATE XI.

Mussel shells from the banks of Headley's Creek, near Tuckerton, holding natural seed at their tips. This seed set in 1906, and was taken September 7th, 1907.

From its position, this seed grew faster than that lying down in the mud.

PLATE XII.

Oyster seed from the Mullica, etc., 1907, sent us through the kindness of G. A. Mott, of Tuckerton.

A. Shows a large shell holding seed set in 1906, and on that is seen the set of 1907.

B. Seed of 1906 as taken in October, 1907.

C. A mussel shell with seed, from Headley's Creek, to compare in size with B; both sets are of same age.

PLATE XIII.

The new power boat for use in the oyster research and scientific propagation work. Length 21 feet, beam 7 feet, twin screws and supplementary sail power. She is seen lying below the dam in Tuckerton Creek.

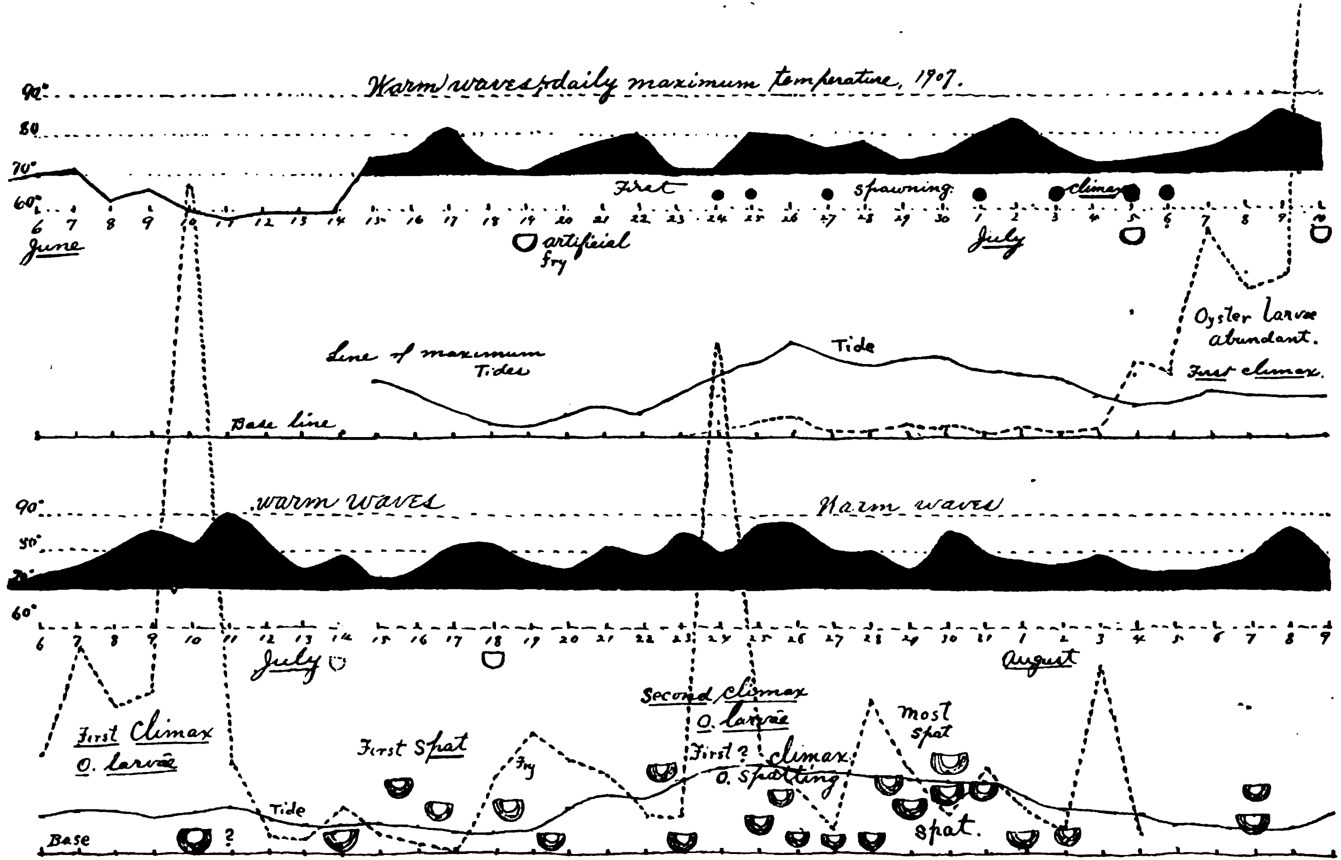


PLATE I. Time chart of Oyster spawning and spatting.

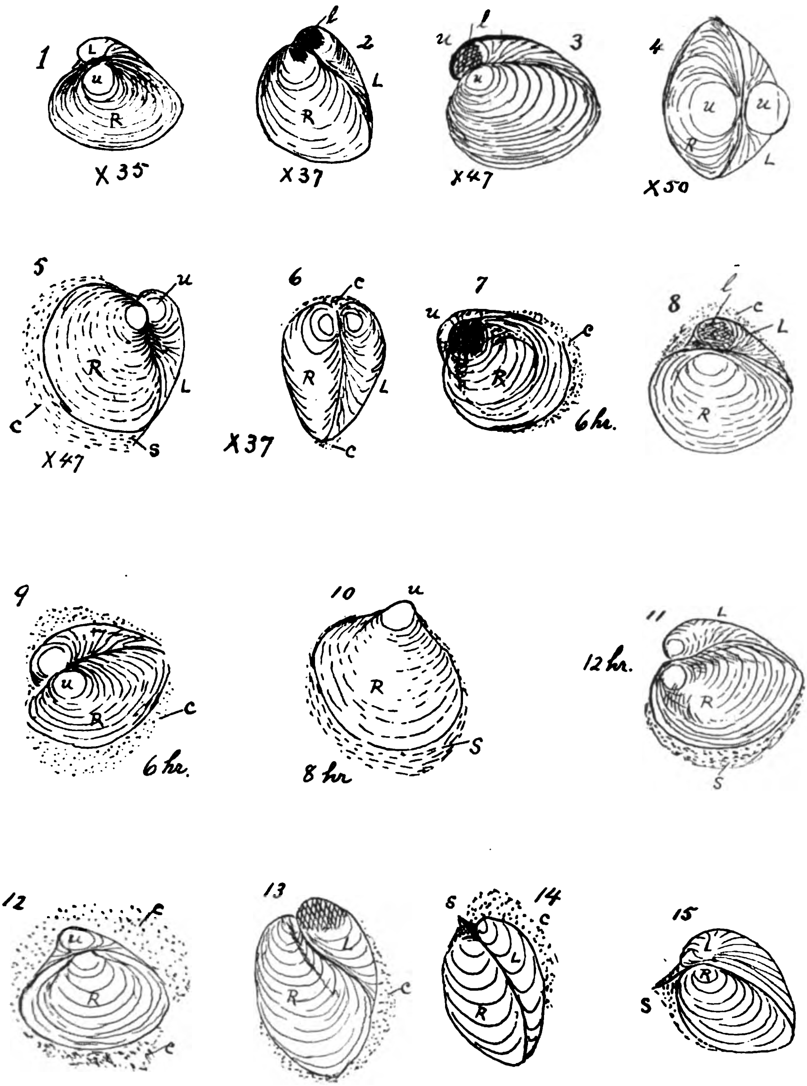


Plate II. Newly attached spat.

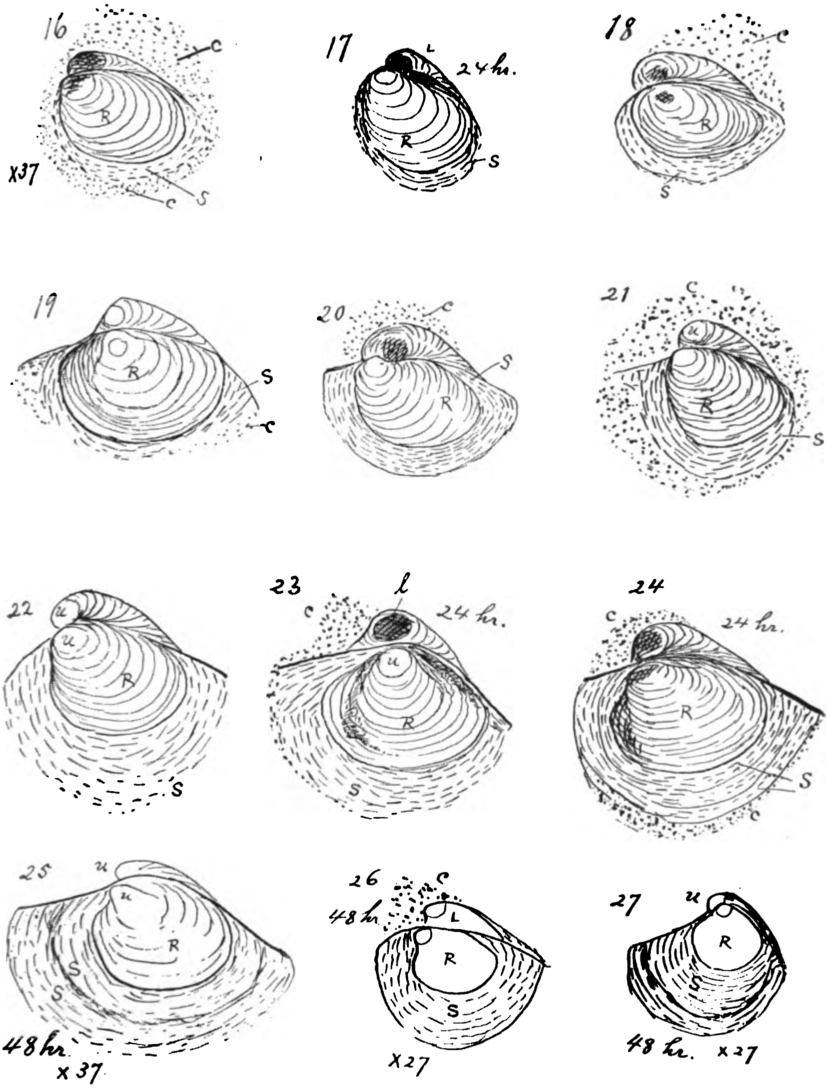


PLATE III. Spat one day old.

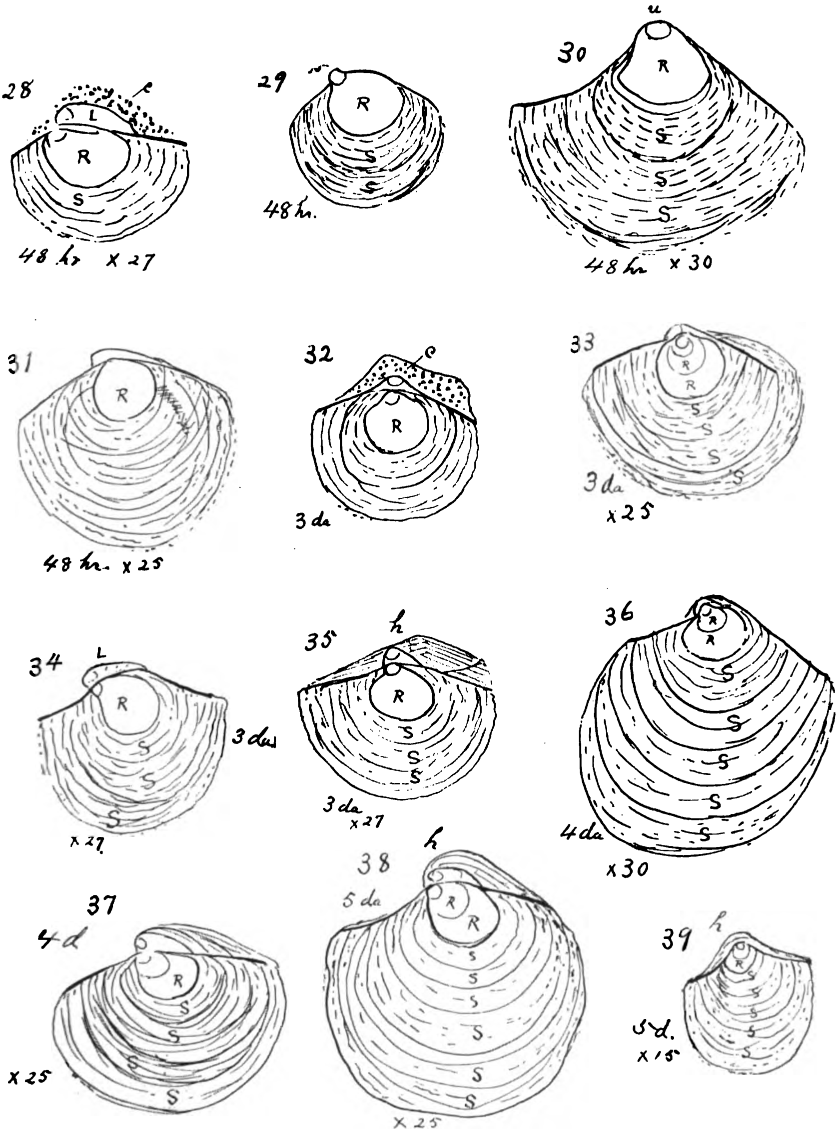


PLATE IV. Spat two to five days old.

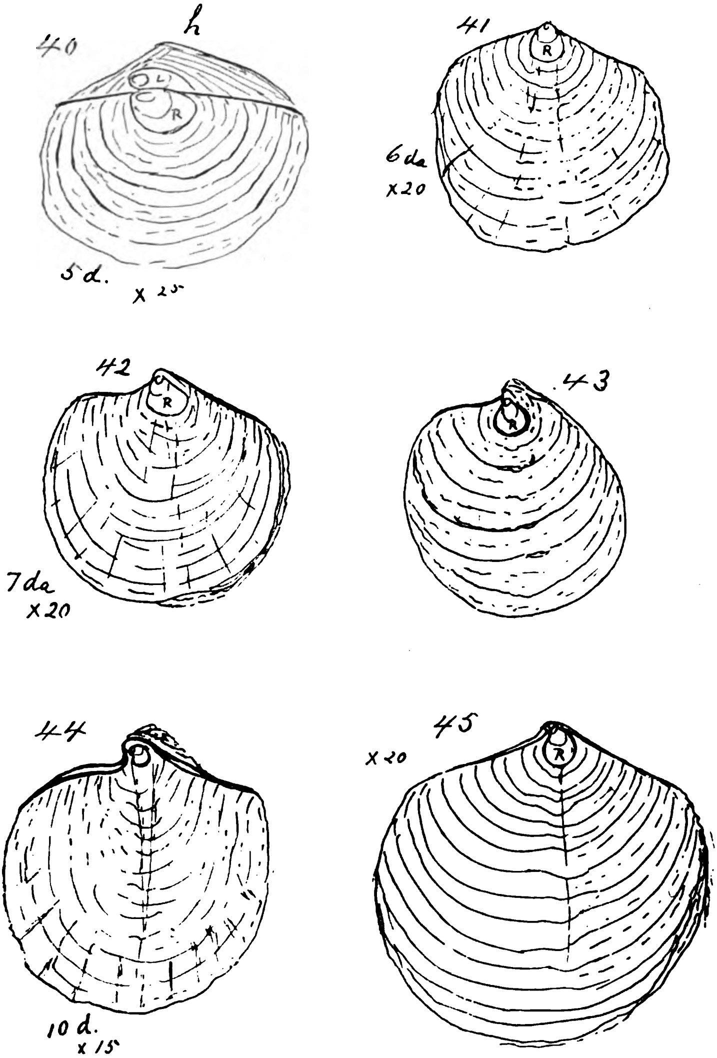


PLATE V. Spat five to ten days old.

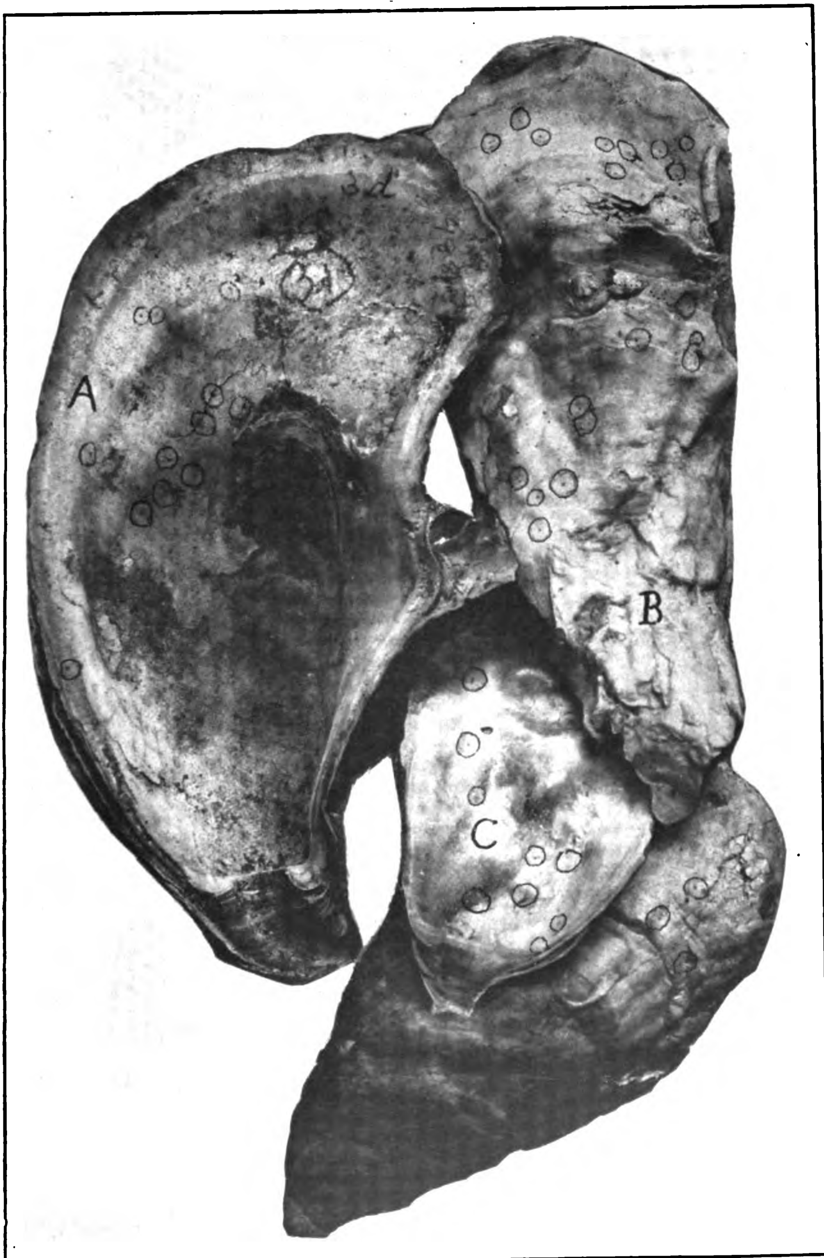


PLATE VI. Oyster spat two days old.

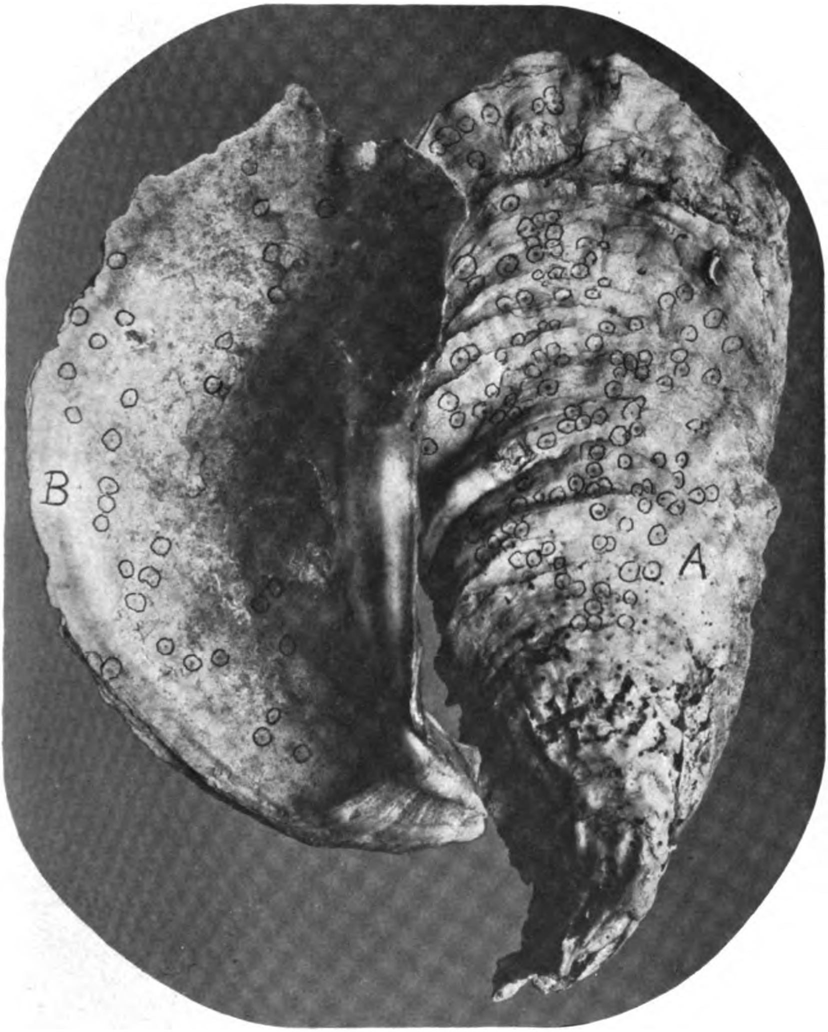


PLATE VII. Three days' catch of spat on experiment shells.

PLATE VIII. Spat, one to three weeks old.

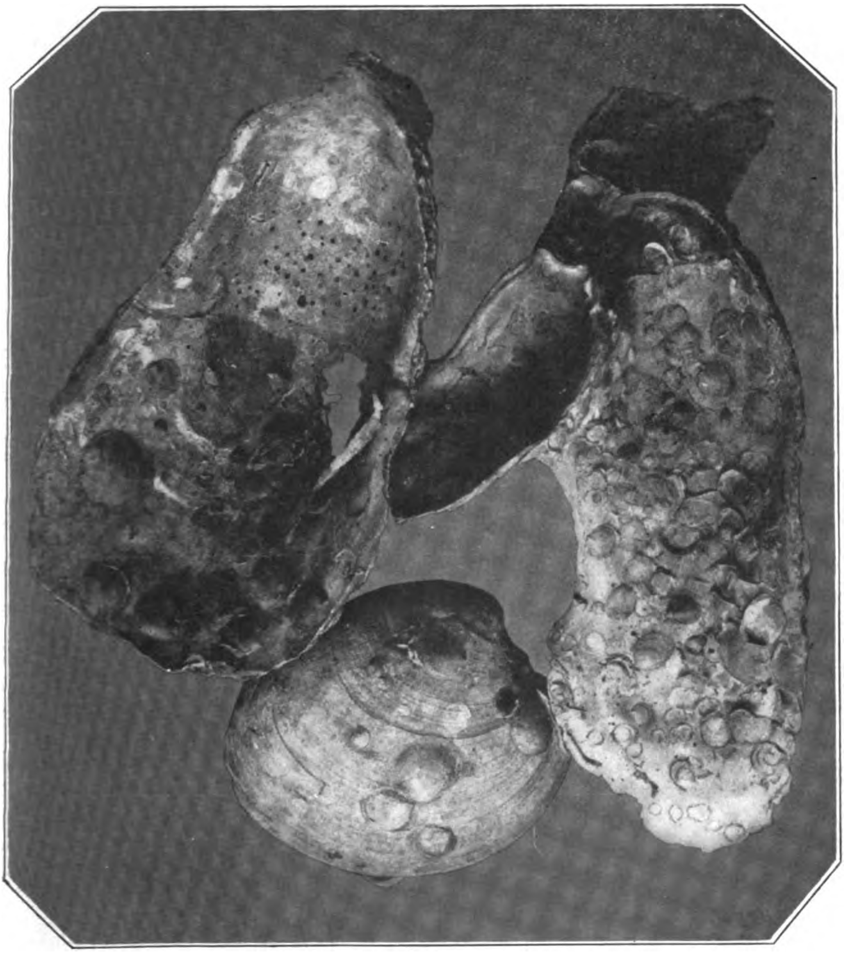


PLATE IX. Barnegat oyster seed, six weeks old.

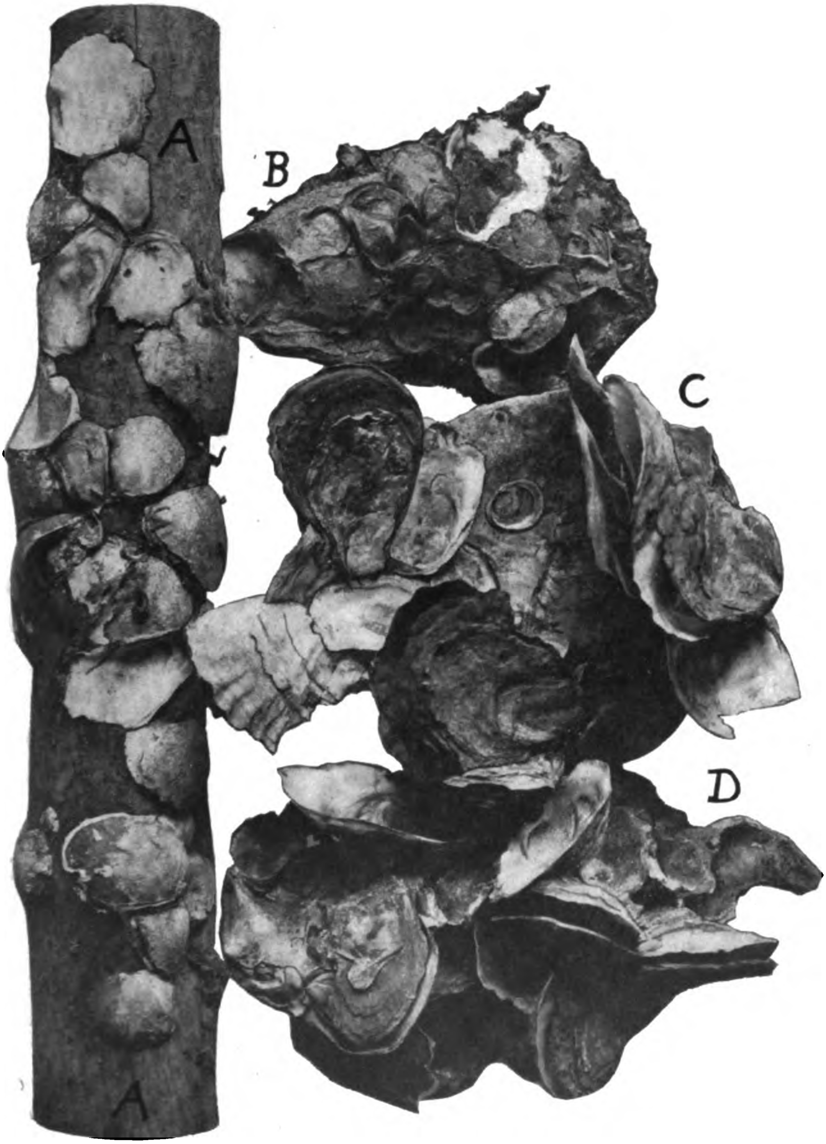


PLATE X. Barnegat Naturals, one and two years old.

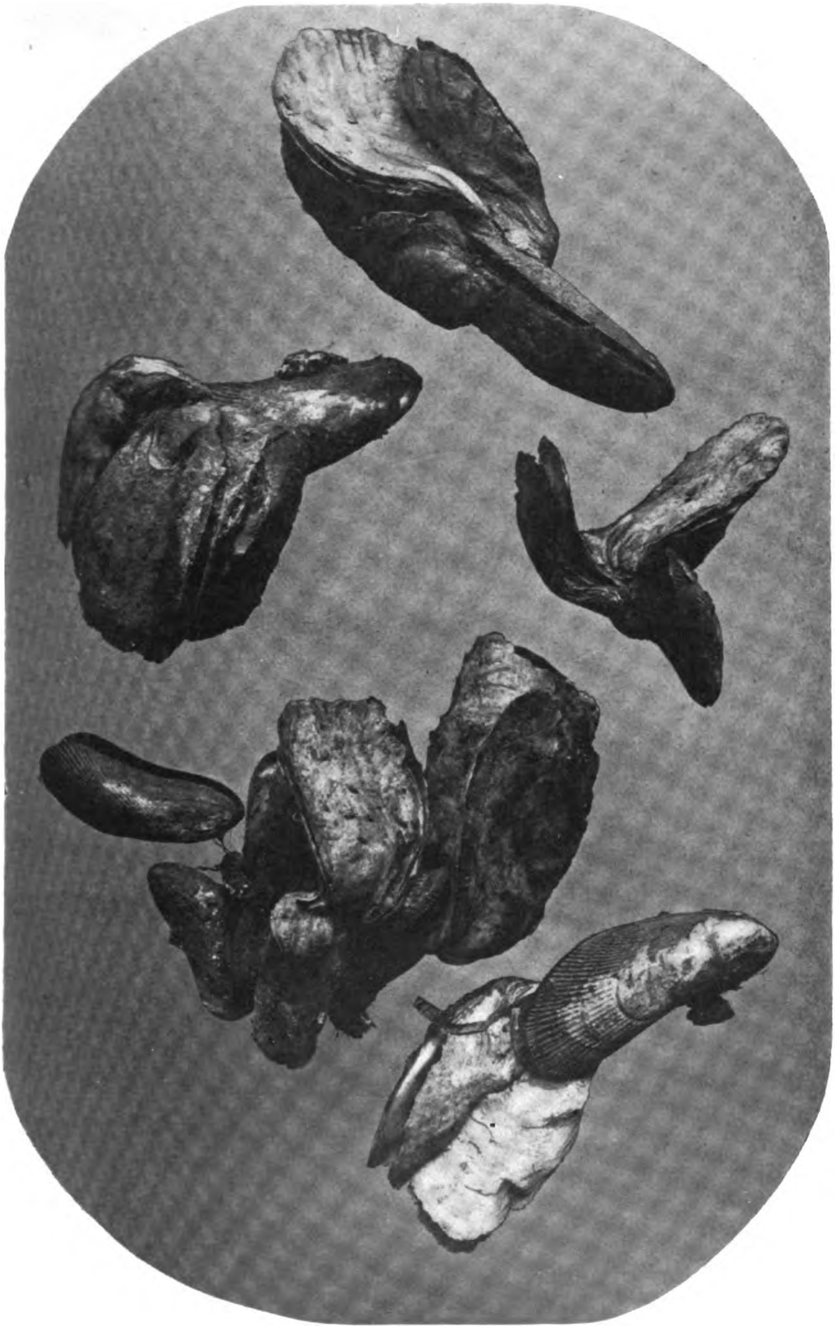


PLATE XI. Headley's Creek "Naturals" on mussels thirteen months old.

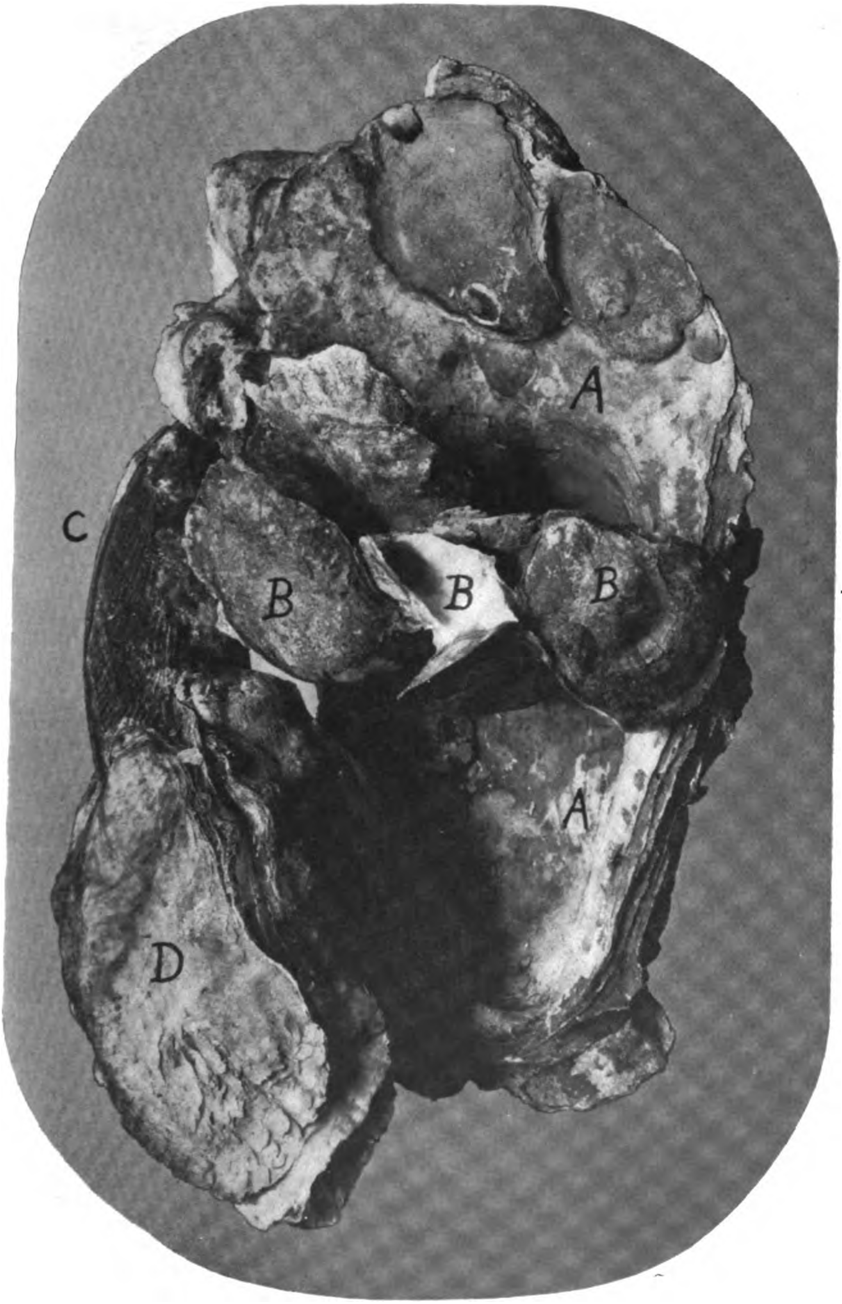


Plate XII. Mullica River Natural Seed Oysters, October, 1907.

PLATE XIII. Oyster Research Boat.

REPORT OF THE BOTANIST.

(257)

Report of the Botanist.

BYRON D. HALSTED, SC.D.

EARLE J. OWEN, M.S., AND NAHUM D. SHORE, B.S.,* ASSISTANTS.

For the year ending November 30th, 1907, the Botanical Department has been working chiefly along the general line of the improvement of truck crops. The test includes sweet corn, tomatoes, eggplants, Lima beans, snap beans, summer squashes, winter squashes, peas, okra, onions and salsify, to which is added some ornamental plants.

The work with sweet corn has been much influenced by the very unusual season, particularly the first portion, when all early plantings were either destroyed or badly injured. The block of "Malamo" corn grown upon the Home Grounds was low in stature and small in crop; and the same terms characterize the block of "Malakosby." The later sorts, where the land was sufficiently rich, yielded fairly well, and some crosses were so satisfactory that seeds will be offered for trial to the truckers of the state. The cross that has been the most productive of all is the "Golden Bantam-Premier" (34/70). Last season the stalks often produced twin ears as Plate III. illustrates in the Report for that year. What with the plants strong, of good height and the ears frequently twins, of good shape and fine quality of kernels, this sort may prove acceptable for the second early crop. The "Adams-Crosby" cross has been carried forward another year, so that now the sweet corn has been separated from the flint (dent) grains of the "Adams." The plants have much of the sturdiness of

* From June 15th.

the "Adams" with its fine plump ears and many straight rows of grains. This is worthy of a trial by those who wish a reliable sweet corn. The crosses of the "Golden Bantam" (an early yellow sweet corn) with the "Country Gentleman," "Stowell's Evergreen," and others are promising to combine the rich, long grains with an earlier maturing of the plant. A large part of the work with the corn crosses upon the "Smock Land" has been neutralized by the unfavorable season and soil, but in many instances seed enough was obtained to prevent the loss of a year in the progress of the experiments.

With tomatoes, the work of the year has been mainly to make progress toward a fruit of marketable size, with a long axis and an interior made up largely of flesh with many small seed cavities. To this end those sorts with a large apple-shaped fruit have been bred with the "plum" and "pear" types of fruits, and it is a pleasure to record by means of a plate that a hopeful advance has been made. Among the two thousand plants upon the Home Grounds, there were some crosses so full of promise that seeds are to be offered for a trial by those who may desire to test them. Some of these are early, while others show merit as plants for the home garden. Some new types have come to light among tomatoes—one in particular combining the "Currant" and "Ponderosa" that is remarkable for both its shape and flavor. As usual, the freaks have not been slow in making their presence known—as, for example, a cross with the "peach" that is deeply ribbed like a squash, and of remarkably large size.

The eggplants did not make as large a growth of plant as usual, the cold, backward spring being unfavorable, but as the season drew to a close the showing of fruit was fine. A large number of crosses were grown, and of these "Long White" upon "New York Improved" (11/18) has given a satisfactory fruit in size, shape and color, and, under the name of "Ivory," its seed will be distributed. Further points of interest have developed among the hybrids between the "American" and "Chinese" species; by increasing the blood of the former the size of the hybrid fruits has been much enlarged, and thus hope is brightened that a combination of economic importance may be made. The way seems open for the production of a truly spineless eggplant.

The bush or snap beans have occupied much of the poorer land recently assigned to the Department, and some of the crosses are so far developed as to make it possible to offer seeds in the coming spring. Crosses of Lima beans have been given more than usual space. All of the leading sorts have been grown, and many crosses between them are upon trial. A study is being made of the "Willow-leaf" types as having a possible advantage over the ordinary sorts in times when the mildew is prevalent. Another generation of the hybrids between the snap beans and "Scarlet Runner" has been grown and the number of types are many, differing in form of vine, leaf, flower, pod and seed. The prolific plants may in some instances be the beginning of hopeful lines that are quite new.

Squashes of the summer sorts were given a place upon the Home Grounds, and out of the fifty and more selected inbred crosses of previous years, a few will be selected as worthy of a place among the commercial sorts. Several new kinds were grown and used extensively in the breeding. The winter squashes did not fare so well, they being assigned to the less fertile land where greater area was possible for them. Many of the crosses failed to mature fruit, but of others satisfactory results were obtained.

The crossing of garden peas, begun last year, was carried forward for a season, and some promising types are in evidence; in August a partial set of these was grown as an autumn crop, without considerable success.

Salsify, okra and onions all received some attention during the year. The Japanese Udo as a salad plant has not met the expectations, chiefly due to a blight that sickened the plants early in the season, from which they never recovered their full vigor.

During the year two bulletins, namely, No. 199, "Station Novelties in Truck Crops," (34 pages, 4 plates, 7 figures), and No. 202, "The Forest Trees of New Jersey" (54 pages, 25 text engravings), have been issued; the first dealing with the distribution of seeds, and the last gave some notes as to the range and culture of the trees of the state. The seed distribution last spring embraced 1087 packets as follows: Corn, 411; tomatoes, 330;

eggplants, 121; winter squashes, 128; "Pak-Choi," 47, and "Pe-Tsai," 50 packets respectively.

Some time has been consumed daily in the determination of the names and habits of plants, the examination of commercial seeds for impurities, the investigation of the diseases of crop plants, and the correspondence connected with the above and allied matters associated with the Department.

THE EXPERIMENT AREA.

The land devoted to plant improvement consists now of seven acres in three separate portions of the College Farm. The Home Grounds have been in charge of the Botanical Department for the past thirteen years, and consist of two acres divided into seven series, each of four plots, as shown by the plan upon page 264. Each plot consists of one-twentieth of an acre, and within the past year has been permanently marked by corner posts of cedar, thus making it an easy matter to arrange the several crops and keep the paths in place both ways of the area, as shown by the double lines in the diagram. There is an irregular piece of ground at each end of the rectangular block of plots and these are occupied with ornamental plants for breeding purposes and grass experiments.

The soil of the Home Grounds is fairly uniform in quality, it being a mixture of clay and gravel, and at the outset was not of the best for garden purposes, but its texture has been much improved by the annual application of manure at the rate of twenty tons per acre for the past thirteen years. These two acres occupy a gentle slope of land and water has been piped along the upper side to the head of each path and, from outlets there placed, irrigation is made easy for the whole area.

Another acre was added to the Experiment Area three years ago and consists of three equal strips, widely separated from each other in a neighboring field. Upon this area, called "The Strips," several of the isolated corn-breeding plots are located, and between them and filling up the strips crossed beans, peas and squashes have been grown. This land is a recent addition to the College Farm, and is not yet brought up to that richness and tilth demanded for the best results in plant-improvement experiments.

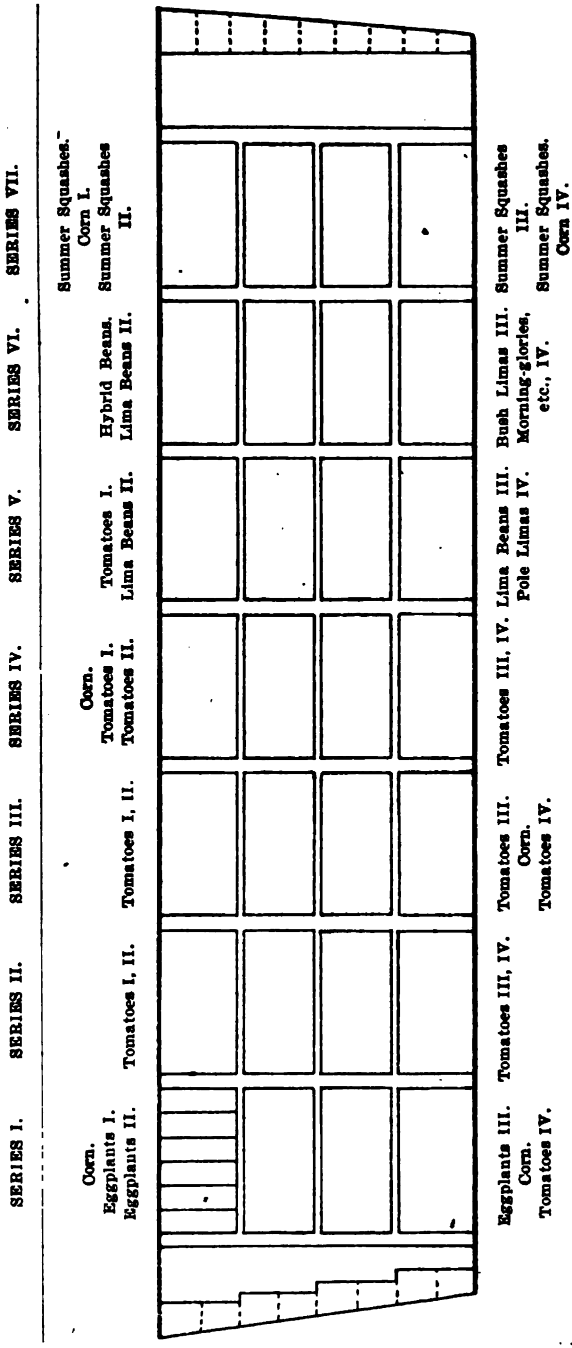
A third block of four acres of land has become available this year for the Department, through the gift of a tract to the College by Dr. J. C. Smock, for various purposes, one of which is forestry and nursery experiments. This "Smock Land" has made it possible to expand the field work, and when the soil, at present in a partially exhausted condition, is built up by green manuring and liberal fertilizing the foundation will be laid for much more extensive and satisfactory experiments along the lines of plant-improvement. Crimson clover, vetch and rye were sown in early autumn to be plowed under in the coming spring.

It is seen that the Breeding Grounds consist of three separated areas and one of these is further divided into strips with land between, devoted to farm crops. This distribution of the land is in large part necessary in order to carry out the experiments with crossed corn, and by means of this adjustment it is possible to grow upon seven acres not less than fifty-two blocks, exclusive of the breeding plot where new crosses are made.

This wide separation of the parts of the Breeding Grounds also permits of the isolation of the special crosses of other vegetables. Thus, a block of peas, beans, tomatoes, or eggplants, may be located a long distance from the general breeding plots and the chances for natural crossing thereby reduced, besides giving a test of the crop upon a more extensive scale.

In addition to the Breeding Grounds above described, the truckers and persons with home gardens only are invited to assist in the general testing of crosses of promise and in this way the experiment area is extended throughout the State and, in fact, the whole United States and beyond.

The Experiment Area for 1907.



EXPERIMENTS WITH SWEET CORN.

Sweet corn in its many crosses was grown upon all three of the areas devoted to plant breeding. Such a crop, because of its wind pollination, precludes the planting of all the corns in a single block, and, in fact, it was on account of this subject in particular that the breeding ground consists of separate pieces of land. Upon the Home Grounds eight blocks of sweet corn were grown, and the times of planting, in connection with the nature of the crosses, were so adjusted that there was practically no cross pollination.

In the first place, a block of "Malamo" was planted near one end of the long rectangle of two acres, and a block of the "Malakosby" near the other. The "Malamo" bloomed first, and there is no evidence of intermixing. Later on, at different intervals, the other six blocks were planted, the three upon one long side of the area with three crosses of "Golden Bantam," namely, with "Country Gentleman," "Premier" and "Stowell's Evergreen." These three blocks were all with yellow grains of the cross, while the three corresponding blocks upon the opposite side of the rectangle were planted with white grains of the above-named crosses. That these blocks produced almost absolutely pure white ears is sufficient evidence that mixing was practically absent.

"Malamo"—("Malakhov-Premo").

Like all the sweet corn grown this season, the stalks, crop, etc., were not up to the standard. The young plants were very slow in making their appearance, and for weeks afterward the sickly seedlings failed to grow. Even with all the discouraging conditions there were many good ears, enough to show that the variety was maintaining its previous record for a very early sweet corn, with a product sufficiently large to make it worthy of the attention of those who wish to grow superior quality table corn for home use. It is somewhat too small to be profitable for market in the present stage in the transition from any kind with large ears to that deserving the name of genuine sweet corn.

Reports from Testers of "Melamo."

"Stalk about four and a half feet high. The quality is all right." "Early but not very large, quality good for an early corn, averaged two ears to the stalk. Plant four to four and a half feet high, rapid and thrifty grower. Planted the 25th of May, picked first corn last week in July, which is very good considering the lot of cold weather we had." "Very early, good flavor." "Planted the same day as 'Minnesota' in adjoining row; the 'Malamo' is much the stronger grower, and apparently more productive. Certainly a fine corn; I find it a fine grower." "Eared well, quality good." "The best eating corn I ever tasted; grows mostly two ears to a stalk; the suckered corn does not have so many ears, but is nicer." "Corn was fine, will say that it is the earliest and sweetest corn I ever raised, had fine table ears in sixty-six days." "I had first corn yesterday; it was fine, nice deep grains well formed, small stalks, ears six inches long." " 'Malamo' is doing well, have had several messes from it and quality is excellent." "Ears solid, sweet, sound, perfect, two on each plant; a few have their length, five and a half inches. A good vigorous early sweet corn, and very desirable." "Sweet, free habit, ears borne at bottom of stalk." "Quality is very good for so early a variety. It is about a week earlier than my best early corn which I have been growing for four or five years." "This corn was a success, it matured in seventy-eight days. The stalks were very short and the ears of good size and well filled and of good flavor." "This is an early sweet corn, is four to four and a half feet high, the ear was well filled. Grains perfect size, seven to eight inches long." "The sample of sweet corn received was very sweet and tender, the ears mostly perfect." "Came up very well with strong stalks and large ears." "Season early, stalks short, ears medium, quite a number two ears to one stalk; grains plump and ears filled to the tip with kernels. I consider it a great improvement over the 'Cory.' " "We have used some of the 'Malamo,' and the quality seems to be good, the ears are about six inches long and most of them have about twelve rows." "Grain firm, sweet, full and very meaty." "Strong growing, good-sized ears, often two on stalk, improvement on 'Golden Bantam,' as it is larger and stronger growing; improvement on 'Country Gentleman,' as it is better quality. I consider 'Golden Bantam' best quality sweet corn, but this cross seems to be as good with larger better ears and not much later." "Germinated extra well, plant medium size, gathered for table use early in

July." "Nine hills were planted about forty inches each way on April 26th. This corn was in the roasting stage July 22d. Three to four ears were harvested from each hill, the picking being continued until August 7th. The flavor was excellent." "This corn is of a very fine quality and very sweet." "I find the 'Malamo' sweet corn grown from the seed sent me to be of good flavor. Large meaty grain well filled to end of ear, the ears are not large, the plant matured in a short time and was of medium height. I should consider it a good variety for an early corn." "Corn very sweet." "Very early variety." "Planted May 22d. Had our first corn July 30th. Plants about five feet in height. Ears six to seven inches long. The quality extra sweet for an early corn, as sweet as most of the later sorts." "Plants of good size, six to seven feet, vigorous, productive, one to two ears, ears of good size, regular, six to eight inches long, well filled, quality good." "Good quality for so early, find it a few days earlier than 'Golden Bantam.'" "Earlier than the 'Burlington White' corn and sweeter. Stalks from three to six feet high. Ears small." "Very early, sweet." "Quality good; I am well pleased with it and will save all I can for seed." "The corn was deliciously sweet, could not have been better. The ears were very small, as were also the kernels. The soil here is very sandy and dry. I felt very proud of the corn." "Grains exceptionally plump, giving ears better appearance after husking than before." "Quality excellent." "It is sweet and rich in flavor. I am satisfied, if properly grown on rich soil, it would be a most excellent early sweet corn." "Plants very strong and vigorous, very handsome shaped ears, quality of grain fine, it is the best sweet corn I ever saw." "Size of plant six feet; large ears, grains of a good size and flavor." "It made a good growth and the ears were of good size; in these respects, it was a great improvement over the Russian parent, which I grew last year." "I like the size of the grains, they are plump and well formed." "The earliest of all our varieties to mature." "Matured early; stalks about five feet high." "Fair-sized stalks bearing very sweet, medium-sized ears." "Plant rather small; ear large for size of stalk, quality of corn excellent."

"Malakosby"—("Malakhov-Crosby.)

As in the previous year, the "Malakosby" was somewhat later than the "Malamo," with the compensating advantage of being larger. The two kinds are easily distinguished while

growing and, in fact, the differences in the field are greater than that between the ears and grain. The "Malakosby" may prove to be a good sort to plant at the same time as the "Malamo," to follow it in the sequence of the harvest of ears for the table.

Reports from Testers of "Malakosby."

"Every kernel planted of this corn germinated, and the plants were very vigorous." "Most of the stalks of the corn, which I planted early in pots, have given me two good ears each. The quality is good." "The quality of this corn is all right." "Very good ears." "Corn is very sweet and tender." "Kernel sweet and skin tender." "Corn sweet, a fine extra early variety." "I am much obliged for the corn, as it was fine. It was nice and sweet and the kernels were large." "Quality of grains decidedly good." "Grains fine, very sweet and full." "Quality good." "An excellent variety almost as early as 'Sunrise' and ears uniform, large and very white." "The quality of 'Malakosby' was excellent." "We have used the corn on table and find it sweet and of good flavor." "Corn of good quality." "Most of the grain of the corn was uniform. The grains were very sweet. This corn is excellent for the table." "Quite early." "Very fine corn and sweet." "Grains large, quality excellent." "I consider this sweet corn very hardy because every hill came up when other sweet corn had to be entirely replanted, having started to plant on May 16th when weather was very unfavorable being too wet and cold. Some ears were ready by August 1st to use for table, and proved to be of very fine flavor and well shaped. The corn stalks are about five to six feet high, earing about eighteen inches from ground and yielding one or two good ears to stalk. Am very pleased to have some of this sweet corn in my possession and intend to plant it for my early corn." "Germination was excellent and appearance is now good." "The sweet corn you sent me this year is very much nicer than last. The ears are much larger and the corn sweeter, and it was as early as the other." "Quality excellent, equal it seems to me to that of the 'Black Mexican,' but the grain is rather shallow. Very early, ready to use fully as soon as 'Black Mexican,' planted three weeks earlier than 'Malakosby.'" "The best early corn I ever planted, stalks small, ears fair size, grain large and deep, extremely small cob. Corn very sweet and fine flavor." "This sweet corn was very early, ready for use even this backward

year, July 15th; the stalks were strong, thrifty, although very dwarf, the ears large for size of stalk and of good quality." "It is a good variety; early but small, short ears. It is sweet and productive, medium size grains." "Plant very small, ear medium, very productive; flavor good and very early."

The Study of Color in "Malakosby" Grains.

The "Malakosby" sweet corn has two quite distinct shades of color to the ears, the one a "straw" and the other has been spoken of as "pinkish." These two shades are not grain characteristics, for the two are not mixed in the same ear; in other words, the ear is either "straw" or "pink," and the cob partakes of the latter qualities respectively. This peculiarity of two shades of ears is equally present in the "Malamo," which, it is presumed, also obtained it from the same source.

As seed was needed of the "Malakosby" for further distribution, grains from the "pinkish" ears only were planted in a block, and the following is the result of the three gatherings of the ears:

September	10th,	14 "straw"	7 "pinkish"
"	27th,	14 "	4 "
October	7th,	61 "	30 "
Total,		89 "	41 "

It is seen that the "straw" ears were two to one of the "pinkish." This test shows that the two colors are not easily separated. It is desired that a trial be made of growing a block of this corn from the straw-colored grains.

"Golden Bantam-Country Gentleman" Cross (34/19).

The plantings of the above cross were made in two plots, widely separated, the one with yellow and the other with white grains, both from four zigzag ears. Furthermore, the two plots were divided into halves, the one half (sixteen hills) being planted with long grains and the second half alongside with broad grains. As early as August 16th, it was noted that the plants in two rows

from long grains were taller than those in the adjoining two rows from broad grains, suggesting a possible correlation between length of grain and stalk. At the time of full growth the difference was one foot, on an average, in favor of the plants from the long grains. Those from the broad grains matured earlier, and ripe ears were first gathered from these two rows upon September 4th, or one hundred and eight days from time of planting. Upon the 25th the ears were gathered for the photograph* as shown in Plate I. The five ears in the upper left hand corner represent the crop from the long yellow grains, ears 1 and 2 and 4 and 5 being twins, respectively, while the one at 3 gives an idea of the type of ear borne singly. In like manner the set of five ears, 6 to 10, shows two pairs and a single (8) from the broad grains.

A careful inspection of the whole crop does not lead to any conclusion as to the influence of the shape of the seed grains upon the progeny in a cross. A much more extended experiment is needed, but there is some indication that a broad grain may produce shorter and earlier plants than the long grains from the same cross.

By an oversight in harvesting, the ears of all four rows were gathered together so that the relation between the shape of grains and number of straight-rowed and zigzag ears was not obtained. There were one hundred and thirty-five good-sized ears harvested from the thirty-two hills, which was a small yield, but fair as sweet corns turned out the present season. Of the number named, eighteen were distinctly zigzag and eighteen straight-rowed, or practically one-eighth of the whole number were of the types of the two parents.

The lower half of the plate shows sample ears from the plot planted with white seed of the cross in question. From 11 to 15 are two pairs of twins, and a single between them (13) representing the two rows planted with long grains, while from 16 to 20 are five ears, the first two twins and the last three triples from the rows planted with broad grains. As in the case of the previous plot planted with yellow grains, the broad grains pro-

*All photographs used in this Report were made by Mr. F. H. Dodge, to whom many thanks are due for his painstaking skill.

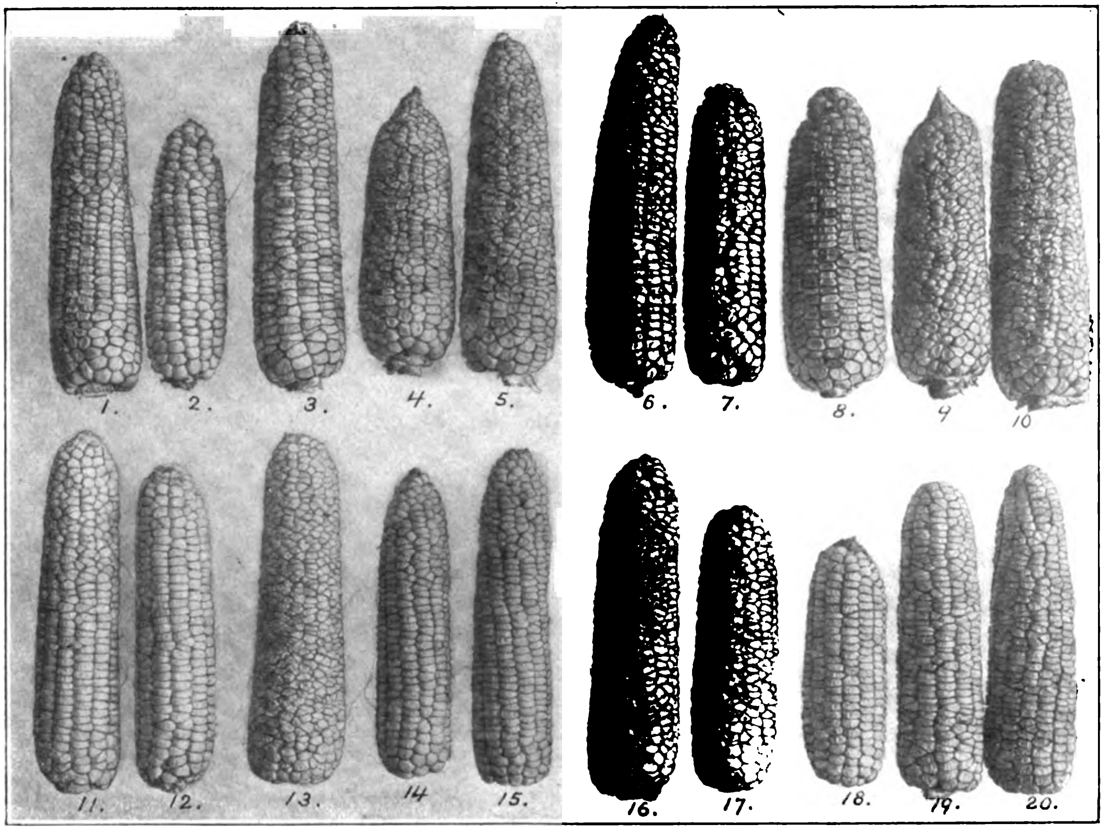


PLATE I. *"Golden Bantam-Country Gentleman" Cross.* Ears in upper rows (1-10) from yellow seed and all twins, excepting 3 and 8; ears in lower row (11-20) from white grains, all twins excepting 13 and 18, 19

duced shorter plants, very uniformly so, and noticeable to any ordinary observer, that were somewhat earlier in coming to table maturity. Concerning the effect of the form of the seed grain upon that of the crop, it may be written that nothing definite was observed. The harvest of the two sets of plants was made separately with the following results: Long grain seed had 13 ears zigzag, 15 ears straight-rowed, and 15 ears mixed, making a total of 43; broad grain seed had 9 ears zigzag, 21 ears straight rowed and 7 ears mixed, making a total of 37.

The long grains gave the better yield of ears, and had a larger percentage of the zigzag type, especially when it is understood that the "mixed" group included any ears that had departed from the straight-rowed. When the two lots are combined, the results are: Zigzag, 22; straight-rowed, 36; mixed, 22; which show that when the seed is from zigzag ears the output of straight-rows is nearly fifty percentum.

The "Golden Bantam-Premier" Cross (34/71).

The above cross gave one of the best crops of all the sweet corns. A block of thirty-two hills was planted upon Plot 1, Series IV., May 18th, the seed being yellow grains from four ears (two twins) twelve to fourteen-rowed. The stalks were stout and of medium height, and bore ears of table maturity August 20th. As seen in the field the ears are long and somewhat slender-pointed, and there is no exposure of the tips of the ears as they mature. The form of the ear is well shown in Plate II., where in the upper half six pairs of twins are shown, those with eight rows of grains being placed to the left. While the seed was all from ears of twelve or fourteen-rowed, a majority of the crop was made up of eigth-rowed ears showing the strong tendency of this cross to keep to the number that prevails in the male parent and frequently met with in the "Premier." For a medium-early sweet corn the three pairs of ears shown at the right hand of the set of twelve under consideration are worthy of remark, and from these it is hoped to select for a further improvement of the type of ear. It may be possible to increase the number of rows and, at

the same time, gain an ear that is cylindrical and not eight-rowed and taper-pointed.

In this block there were 166 ears of suitable size for seed-saving and many small ones, some of which were the third upon the stalk. A photograph was secured of six sets of triplets when all the ears were large enough for the table. Whether these grains are the best for planting is a matter of conjecture, but some uncertainty will be removed by the ear test for vitality and strength of germ that is made during the winter season. Of the whole number of ears saved fifty-two were solid yellow—the first and the fifth pair counting from the left being among them, showing that there was no adherence to the "Golden Bantam" type when the color agreed with it; in other words, one character, like color, is not necessarily correlated with another. The mixed ears numbered one hundred and four, which happens to be just double those with solid yellow—an instance agreeing perfectly with the expectation under the Mendelian law. After the excluding of the white grains from the parent ears there were one-third pure yellow grains and two-thirds of mixed blood, but with the yellow present and prohibiting the separation of the two lots. As before pointed out, the yellow strain of any cross between a yellow and a white sort will constantly show white grains, but in uniformly diminishing numbers, provided that the white grains are always rejected before planting.

On the other hand, the white strain (because carrying no yellow) is separated, at once and finally, from the ears of the blend plants, provided only that the crop therefrom is successively grown under isolation. In the present instance the two blocks of the cross in question were grown upon the Home Grounds. and the nearest hills were about one hundred feet apart. There were not more than twenty grains of the yellow upon the 155 white ears that were gathered for seed. In the set of six pairs of these ears shown in the lower half of Plate II. there was but a single yellow grain, and it may be seen in the upper half of the leftmost ear. It is not advocated to have less than fifty yards between two blocks of breeding corn, and much more is better, but in the present instance the mixing was but the slightest, and is permissible for the yellow marks itself, and such grains are easily excluded,

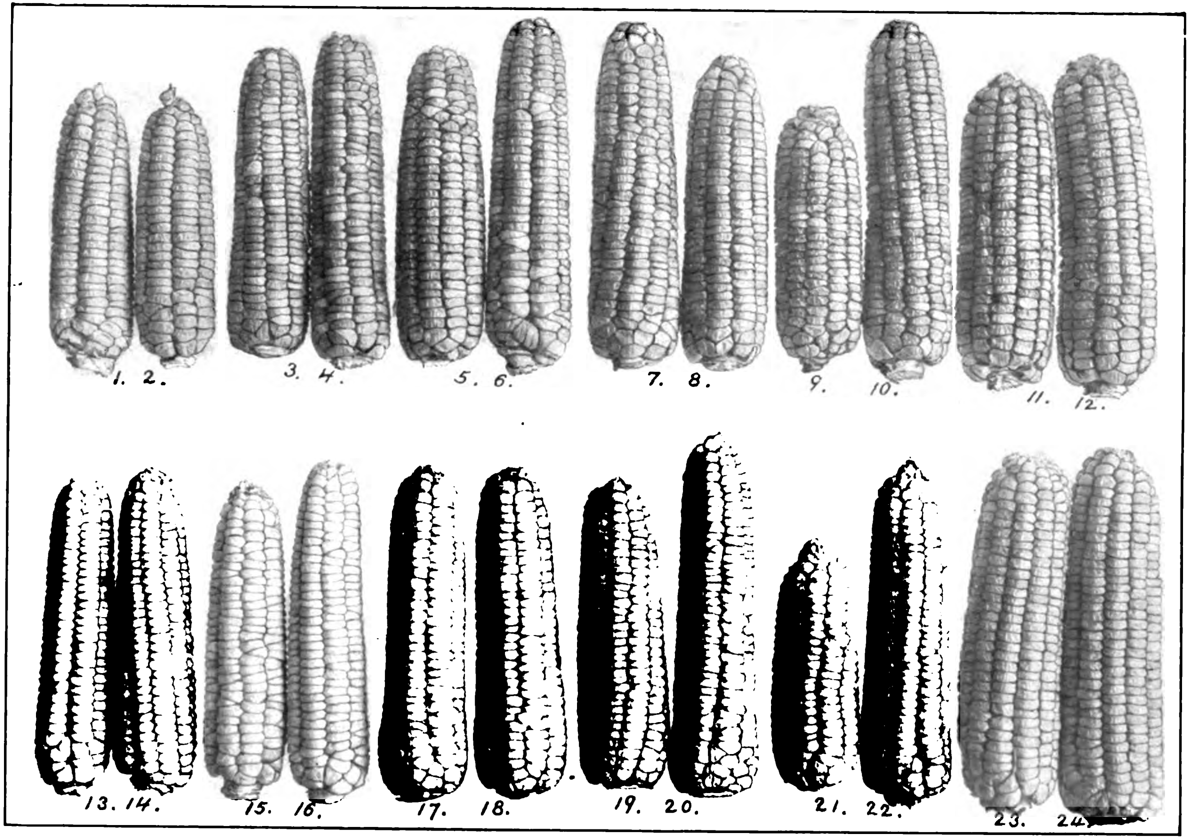


PLATE II. *"Golden Bantam-Premier" Cross.* Ears in upper row (1-12) from yellow grains, each pair being from

and, as for the white upon the yellow, it is the same cross and does not add any vitiating element.

The white ears were practically the same as the mixed in number, there being, perhaps, more of the triplets among them—but they are not quite as large as the mixed ears, a difference, however, that may be accounted for in soil conditions, for the block of white corn was upon lower ground, and the plants suffered much more during the long, cold, damp spring.

Seed of the two strains, namely, (1) the yellow and (2) the white, will be offered for distribution provided only that the set standard for the germination test of the ears is met.

Reports from Testers of the "Golden Bantam-Premier."

"Ears seven inches long, with good-sized kernels; superior to 'Burpee's Golden Bantam.'" "Corn very sweet; grew quicker than the 'Bantam' itself." "Planted May 23d, eaten August 17th, stalks six to seven feet high, two ears to a stalk, good-sized ears. Grains same size as 'Golden Bantam;' a few white grains. Quality as good as 'Golden Bantam,' and it will be of great use if it will breed true to type." "Quality good." "Very sweet." "Eighty-eight days from planting I gathered the first mess from this corn. I pronounce it an excellent variety." "Plant strong grower, ears medium, quality of grain good, very nice cropper." "It did well, two ears to a stalk, ears large size, first ears to eat August 15th. Very sweet." "The sweet corn is of fine quality." "The corn is delicious; it is hardy and productive." "Corn was excellent, very sweet, medium-sized ears; as good corn as I ever tasted, and so said all who ate it." "An excellent variety; ears medium to large, well filled. Deep, large kernels, cob small. Quality closely approaches 'Golden Bantam' both in texture and flavor; a few ears seemed to be sweeter than 'Golden Bantam.'"

The "Golden Bantam-Stowell's Evergreen" Cross (34/83).

Selected yellow grains from two pairs of twins were planted in thirty-two hills in Plot 1, Series VII., rather late in the season (May 18th) on account of the unusually backward season. This plot made the heaviest stand of plants upon the Home Grounds,

largely on account of the late planting. Upon August 17th the plants were past bloom, and upon the 29th (103 days) the ears were tested upon the table, they being of fine size and shape and of superior quality. The harvest was made at several dates, the ears being kept in separate lots. A violent rain and windstorm prostrated the plot of plants, which interfered somewhat with the study of the plants during the last weeks of their season.

In the upper half of Plate III. is shown a dozen ears of the cross in question, all of them pairs of twins. The first pair upon the left and the next to the last to the right are solid yellow, while the others represent the main crop of mixed ears, the yellow outnumbering the white grains three to one. The ears, as may be seen from the samples, follow the "Stowell" parent to a large degree and are, therefore, not small and slender and eight-rowed like the "Golden Bantam." For ordinary purposes the ears are large enough, of a desirable cylindrical shape and, when grown singly, are well filled out to the end. Without any intention of showing this feature, it is to be seen that usually one of each pair—the older to the right—has the good characteristic here in mind. The grains are not as long as the "Stowell," but it was expected to lose somewhat in this respect in getting an earlier corn. When the cross under consideration is improved by selection there is much hope of getting a medium crop, large-eared, high quality sweet corn, and it may be either yellow or white, as the grower chooses, for out of the same cross, both colors are produced. In case of the yellow, there will be some white grains lingering unless close breeding within the plant is resorted to, when a possible weakness may result. There is a large field for experimentation here in the fixing of qualities, making the crosses absolutely uniform and, at the same time, keeping them up to the desired standard of vitality and fruitfulness.

In the lower half of the plate is shown a set of six pairs of twins from the plot planted with the white grains of the "Bantam-Stowell" cross, and not a single yellow grain was found in the whole lot, which shows that the white grains do not hold latent any yellow color. This plot was planted early and was out of bloom before the later block of the same cross, but from yellow seed, was in flower. In fact, it was planted too early, and many

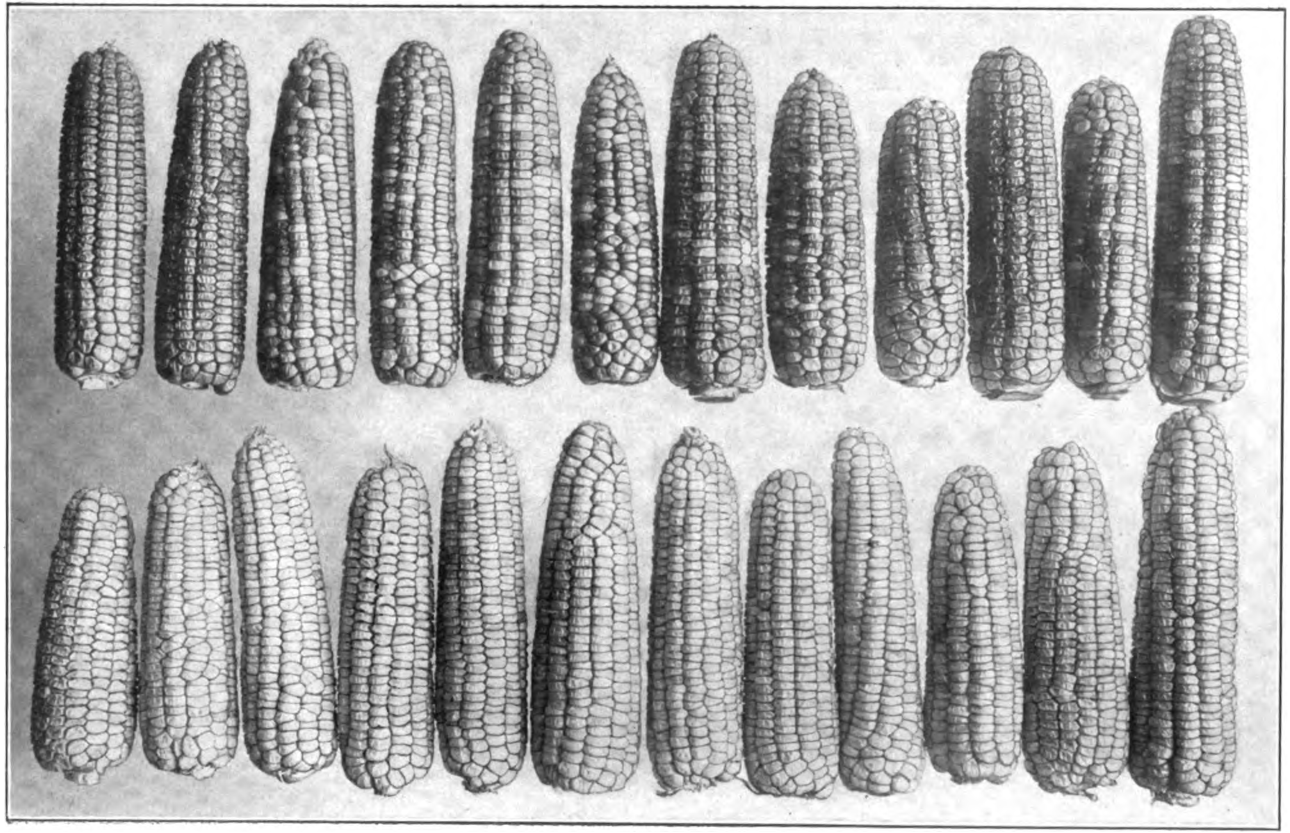


PLATE III. *"Golden Bantam-Stowell's Evergreen" Cross.* Ears in upper row (1-12) from yellow grains, each pair being from same stalk; ears in lower row (13-24) from white grains and represent six pairs of twins.

of the grains failed to germinate in the cold, wet soil, and the crop was decidedly inferior to the later lot. This is easily seen from the samples shown in the plate. If the yellow seed had been planted in place of the white, and *vice versa*, the results, probably, would have been in favor of the white, for it is not likekly that there is a correlaton between the color of the grain and any hardiness of the kernel or plant issuing therefrom. The flint or wrinkled nature of the grain is quite a different matter, as in this instance the hardiness of the grain withstands unfavorable conditions far better than the soft, sweet grain, and the former may live through a cold, wet period after planting, when the wrinkled ones would rot. It is on this account that such early table sorts as the "Adams" are planted as a first crop.

Corn Upon the "Strips."

As before stated, the Department has an acre of land in three long strips that extend across a large field. At the ends and across the middle of each of these strips, plots of corn are planted for isolation; first, nine early maturing sets, and close by these nine plots shortly after, as many later maturing crosses are planted, thus giving isolation more or less complete to eighteen small plots of corn.

The "Adams-Crosby" Cross (2/20).

From blend ears that last season bore three-fourths flint and one-quarter sweet grains, the former were selected and planted May 8th in Plot 1 upon the "Strip." Considering the backward season, this plot of sixty (4x15) hills made a good growth that in no small part was due to the flinty nature of the grains that are thereby able to resist the cold and wet of the prolonged bad spring weather. The first harvest of ripe ears was made upon August 31st, or one hundred and five days from planting. It was noted in the record that these early ears were very closely of the "Adams" type. Upon September 11th, nine other ears were ripe and secured, and these also were nearly all solid dent. At the first harvest only the best ears were selected for study and

record, and of these the entirely flint ones numbered fifty-six, and the mixed one hundred and six, that is, practically one-third were solid flint and two-thirds weremixed—samples of the former being shown at the upper left hand corner of Plate IV, and the latter to their right. A count was made of the flints and sweets upon ten of the mixed ears with the following result: Flint, 3427, sweet, 744, which is a much smaller percentage of sweet grains than expected under the Mendelian law.

As a rule, the mixed ears were of a more desirable shape and size than the flint ones, as may be determined from the six samples shown in the plate. It seems to be true that the sweet grains interspersed upon the mixed ears are as thoroughly wrinkled and free from the starchy nature of the flint as those from ears where all the grains are sweet. At first sight, the origin of the flintiness, often noticeable in sweet corn, does not appear to be due to admixture of the "blood" of a flint corn by a recent cross.

Plot 2 was occupied with a set of plants grown from the sweet grains selected from the same ears that furnished the seed for the plot last considered. The plants of this set, sample ears of which are shown in the lower row of Plate IV, were somewhat smaller than those for the flint grains of the cross in question, but this is probably as expected, the grains and seedlings therefrom being more influenced by the cold, damp spring weather. The ears, as a rule, are less well filled out at the tips than the mates in Plot 1; other than this the ears are desirable in general shape, but need much selection to develop a uniformity in the number and directness of the rows. The set contains purposely some ears from the early harvest, which are dried out and the grains shriveled, while the others are nearly freshly picked. A large majority of the ears are solid sweet, but two in the engraving show a few flint grains that, it is presumed, came from Plot 1. As both plots are of the same cross, they might have been grown side by side and no harm from mixing of varieties would have come. In other words, the flint grains are all "Adams-Crosby" cross, as likewise the sweets wherever found in the two plots.

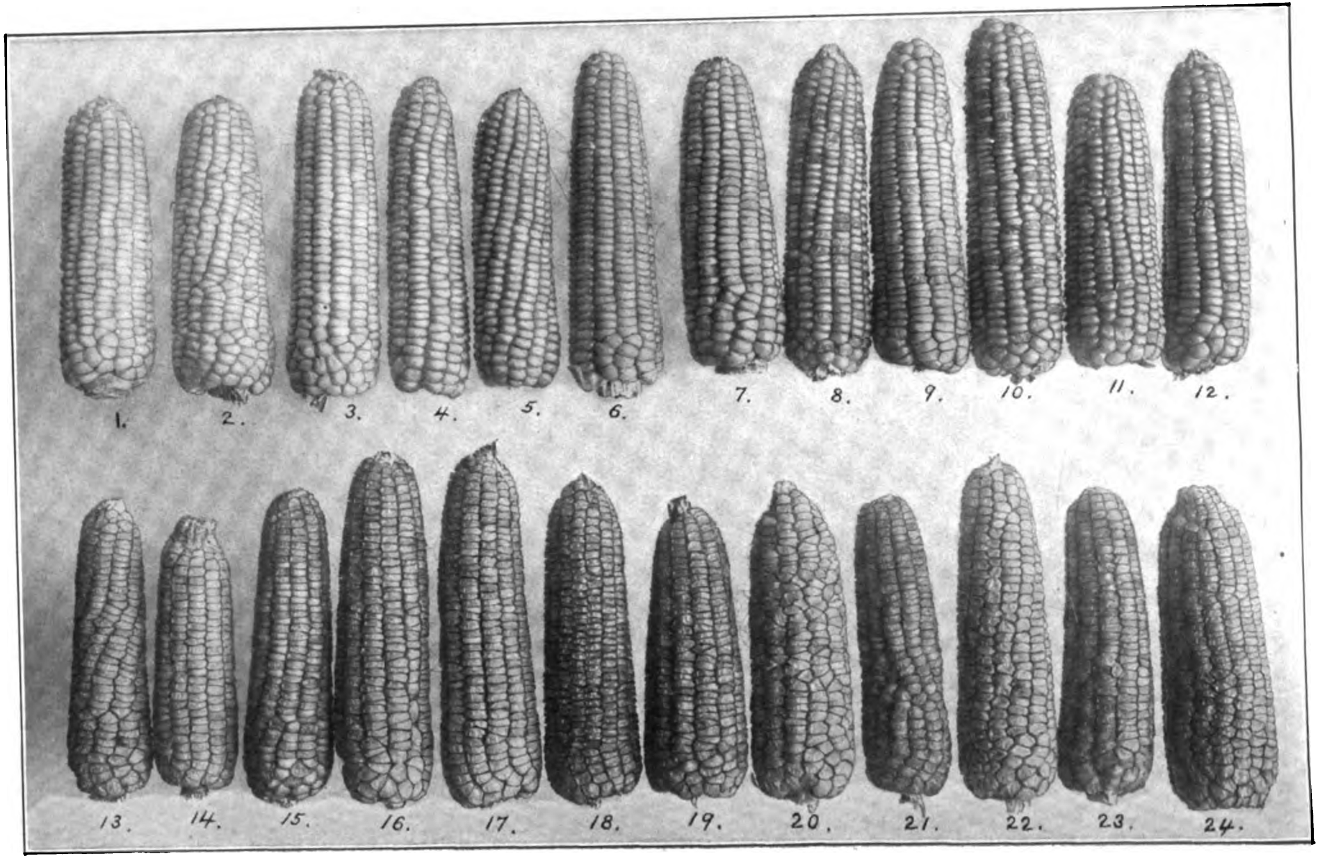


PLATE IV. "*Adams-Crosby*" *Cross.* Ears from 1 to 6 show types of solid flint, from 7 to 12 with a small amount of wrinkled kernels, and the lower row, ears of the sweet kind, some of which were photographed green and others dried.

Reports from Testers of "Adams-Crosby" Cross.

"Planted April 17th, cut it August 1st. Stalks about six feet high. The ears are about half as large again as 'Malamo' and 'Malakosby.' The quality is all right." "Quality of the very best." "Stalks about seven feet high, vigorous, medium-sized ears, large grains, sweet and tender, a desirable garden corn." "Quality excellent, sweet and tender, very juicy. Altogether a valuable corn." "Corn averaged six and a half feet tall. Strong grower. Ear large in the round, and from six to ten inches long. Kernels nearly all in straight rows lengthwise of the ear. Generally one ear to stalk. Quality of grain considered very fine, was sweet and tender." "Four to five feet high, small ear, quality very good." "Some ears were very large and with deep kernels of fair quality, others with short kernels and large cobs. Usually two ears to the stalk, few suckers."

"Golden Bantam-Banana" Cross (34/6).

The three plots of Strip II, that is, Nos. 4, 5 and 6, were planted with the "Golden Bantam-Banana" cross. In Plot 4 yellow grains from zigzag ears were used, and gave a superior block of corn, considering the unfavorable season. Upon September 10th the earliest mature ears were gathered, one-quarter of which were zigzag. The total of all the ears of suitable size for seed was one hundred and thirty-five, twenty-eight of which were straight-rowed. There were no pure yellow ears, but all were with a quarter of white grains. The record states that there were none of the pure zigzag type, but one hundred and seven had the grains more or less out of line.

This block of corn was superior in yield and size and form of ear to the "Bantam-Gentleman" cross, previously considered as grown upon the Home Grounds, but otherwise they resemble each other, and no plate is needed to show the "Banana" cross.

In Plot 5 yellow grains from straight-rowed ears of the above cross were planted. This block chanced to be upon a very poor spot of ground, and the crop was small and consequently inferior to the block last mentioned. The first harvest of ears was made upon August 29th, showing that the cross was more rapid here

in ripening, which may have been due to the drier locality. Only thirty-six ears of marketable size were secured, all of which were staight-rowed excepting two, which were somewhat zigzag. The grains were three-fourths yellow upon the ears generally, but with four the kernels were all yellow, that is, one ear in nine of the whole crop was solid yellow.

Plot 6 was planted with white grains from straight-rowed ears of the above cross, and, here again, the yield was so small as to interfere with the results that it was hoped to secure. There were twenty-three ears of fair size, all of which were pure white but one, and straight-rowed with three exceptions, in which there were strong signs of the zigzag type.

The three plots with the "Golden Bantam-Banana" cross as a whole gave much hope of securing an acceptable (1) medium early, yellow zigzag, and (2) straight-rowed strain, and from the white grains a corresponding pair of strains, namely, (3) zigzag and (4) straight-rowed with the yellow of the "Golden Bantam" omitted. The three blocks show that seed from zigzag ears is quite apt to reproduce its type, and the same is true of the grains from the straight-rowed ears.

Reports from Testers of "Golden Bantam-Banana" Cross.

"I find this a very good and early corn, the stalks are about five feet high, nearly every one has two ears to a stalk, the ears are about eight inches in length; I planted some 'Evergreen' the same day, and it was thirty days later. I consider it a first-class early corn." "This sweet corn is large, tender and very sweet, height of plant about six feet high, corn is very fine." "The corn made a vigorous growth. Stalks were two-fifths of the 'Bantam' type, and the rest were tall. Ears were six and seven inches long. The grain was short, with a hard skin, but sweet." "The plant is six feet high, the ears are very fine, seven inches long, and the grain is uniform, very juicy, well filled and large. I prefer it to any other." "Was very nice, so sweet and fine flavor." "Corn was of excellent quality." "The best of the 'Golden Bantam' crosses. Medium sized ears, well filled, with deep kernels. Quality good."

A Test with Flinty Seed.

The "Malamo" sweet corn has shown a tendency to develop some starch in the grains at the expense of the tissue that abounds in sugar. Such grains are easily seen while they are upon the cob, as they wrinkle less than the others and the starch-bearing interior shows through, giving a lighter appearance to the grains. These kernels have been termed "flinty," in distinction from the pure flints upon one side and the "sweets" upon the other. It is not presumed that the flintiness in question is due to any immediate influence of pollen from any flint corn that may chance to have reached the young sweet ear. When this last event happens, so far as the writer knows, the grain is a flint comparable with the male parent in the accidental cross.

The flintiness in question is usually only partial, and if a large number of varieties of sweet corn are examined it will be found to range from an almost indistinguishable amount to that where the grain is not easily separated from those that are unmistakeably pure flints. The great bulk of the grains showing flintiness are, however, wrinkled and show one mass of no great size that is starchy. An examination of the most truly sweet grains shows that there is some starch present, and it is by an increase of this that the flinty grain is produced. Whether there are any sweet corn grains that have no starch in their interior remains to be demonstrated, but it is assumed that any large amount is not a desirable feature, as it allies such grains to the starchy sorts that are not table corns in any true sense.

A field test was made the present season concerning the power flinty sweet corn has of reproducing its kind. A block of sixty hills (Plot 9) of "Malamo" was planted with grains showing flintiness, and at the same time, a similar block (Plot 8) was planted with grains of the ordinary type. The season was so unfavorable that the crop was small upon both blocks, and in this regard the two plots were served alike, but it is apparent that the unfavorableness for a good crop may have a tendency to develop the flintiness. From the crop of each plot twelve ears were selected that showed the most of the flintiness, and are given in

Plate V. There were a few ears from the block planted with ordinary sweet grains that showed a flintiness, and these are arranged to the left in the upper row, that is, the ears are placed with the ones showing most strach-bearing grains to the left. The set of twelve ears from the block planted with flinty grains, given in the lower row, all show the starchy kernels in great numbers, and no attempt was made to arrange them upon the basis of flintiness.

This test, so far as it goes, shows that flinty grains tend to reproduce their kind, and suggests the natural opinon that all ears of sweet corn that show starchy grains should be rejected.

It is not the purpose here to enter into any philosophical consideration of the subject, either as to the origin of the flintiness or its value in the economy of the plant. It may be a tendency to revert to the original type which was starchy, the influence of some previous breeding with a flint sort, a way that the sweet corn has to compete with unfavorable conditions that the suffering mother hands down to the offspring, etc. Whatever the cause or combination of causal conditions, the practical fact is that the highest type of sweet corn is not considered as having flinty grains, and all such may well be rejected at planting time.

"Voorhees Red" Selection.

The only plot in the "Strip" not previously described (No. 7) was occupied with forty-five hills of the "Voorhees Red" sweet corn, planted from a single twelve-rowed ear. The crop shows some variation in the plants and ears, and an occasional white grain was present, as naturally expected from the nature of the original cross ("Black Mexican" upon "Egyptian"). From the plot some of the best twin and single ears, all solid red, were saved from plants previously labeled for their good qualities, and the work of further selection will be continued.

Second Set of Plantings upon the "Strips."

Upon June 20th a second set of plantings was made upon the "Strips," the blocks containing twenty-five (5 x 5) hills adjoining the plots that were planted May 8–10th. The whole nine blocks

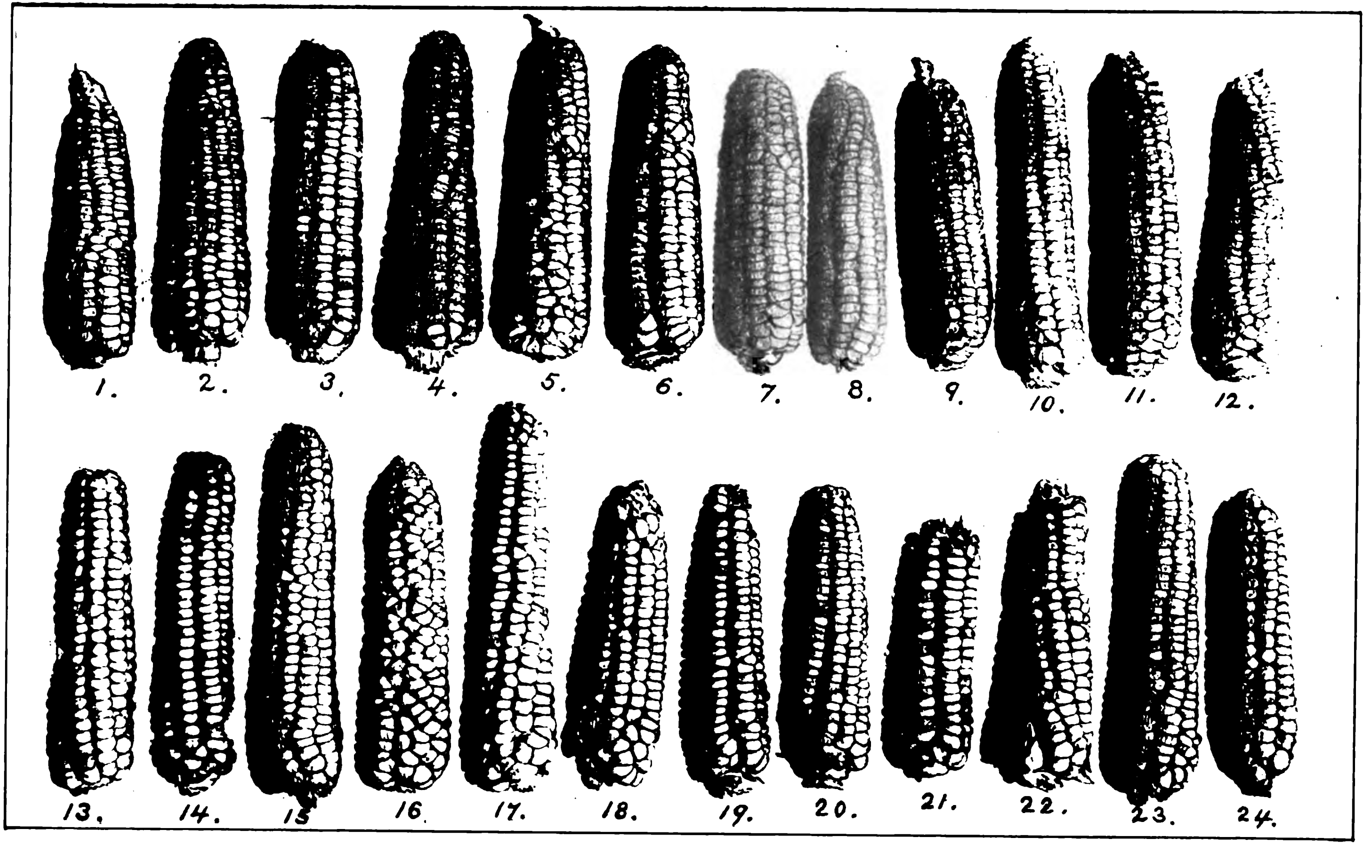


PLATE V. *Test for Flintiness in Sweet Corn.* Ears in upper row (1-12) are of "Malamo" under ordinary culture; lower row (13-24) shows ears of same variety grown from selected flinty grains.

Plate VI. *Blend Ears of Field and Sweet Corn.* "Silver Mine-Stowell" at 1; "Silver Mine-Country Gentleman" at 2; "Silver Mine-Old Colony" at 3, and "Silver Mine-Metropolitan" at 4. At 5, 6, 7 and 8 are representative ears of "Pride of Nishua" upon "Stowell's Evergreen," "Country Gentleman," "Old Colony" and "Metropolitan," respectively.

concerned the crosses that were secured the previous season of "Iowa Silver Mine" (144) and "Pride of Nishua" (145) upon various sorts of sweet corn and recorded in the report (with a plate) for 1906, pages 396–401. The "Iowa Silver Mine" is one of the leading white dent varieties grown in the Middle West, and was obtained along with the "Pride of Nishua," a yellow sort, from a breeder of field corns of distinction in his region.

The points in mind in securing these crosses were many, some of which were strictly practical, while others partake more of the theoretical nature. Last year as breeder rows the two Iowa field corns grew to the height of nine to eleven feet, and overtopped the varieties of sweet corn among which they stood. It is possible that some addition to the size of the stalk and vigor of growth may be an addition to table corns, provided there is no great sacrifice in quality. The longer period of growth does not lead to any hope of securing an early sort in this way, but, if additional strength of plant, handsome ear and desirable length of grain, with sweetness and prolificness are secured, there are ways in which speed may be added to such a type of corn.

Let it be noted here that the planting of the set of crosses under consideration was made as late as June 20th, that the season was not of the best for the crop, and in September all the plants were prostrated and partially uprooted by a heavy wind and rainstorm, that after being reset they were again torn down two weeks later, and killing frosts came upon the tenth of October. And yet, after all these vicissitudes, on the fourteenth of October a set of ears was taken from the badly broken stalks that is shown in Plate VI., one hundred and sixteen days from the time of planting.

Plot 1 was planted with seed from an "Iowa Silver Mine" ear that was produced in the breeder row of last season as a kind of check or means of comparison of the crosses grown in the other plots. The plants were of the large type characteristic of the variety, but much smaller than when grown under the favorable conditions that surround this field corn in its home in the highly fertile soil of Iowa. The ears in the present crop showed many sweet grains, thus indicating that the dent grains used as seed carried in latent form the sweet character which became manifest

in the kernels of their progeny when both the combining germs contained the character of sweetness as against those with the starchy quality.

Plot 2 was a variable plot of stalks, some much larger than others. Number 1 in the plate represents the sample ear gathered before the others for the photograph. In this instance, as with all the others shown in the same plate, the ears are not the choice of the husked crop, but a single one taken before the others with the hope that the leaving of the bulk of the ears upon the stalks for a few weeks more might improve the grains for future planting. This "Silver Mine-Stowell" ear is of large diameter and fair length, with probably one-quarter of the grains sweet, they being shown as plump, while the starch-bearing ones have already become dented.

Plot 3 was planted with flint grains from "Country Gentleman" ear in the breeding plot of last year, and the plants were of a size and variety that compared well with those of the other plots. A sample ear is shown at 2, and is seen to be of larger size than the average "Country Gentleman" and has its characteristic zigzag arrangement of the grains which are of a very desirable length. Here again, the sweet grains are still plump and are behind the starchy ones in assuming their natural wrinkled shape when dry.

Plot 4 was planted with crossed grains of "Silver Mine" upon "Old Colony" and the result, so far as can be now judged, is quite satisfactory inasmuch as type of plant and ears is concerned. As yet, nothing can be said of the quality of the strain that may be developed from this cross. The ear shown at 3 is perhaps too tapering to suit the fancy of the expert, but it is possible that this is not so evident in other ears. Aside from this, the well-filled out tip is quite acceptable.

Plot 5 contained a block of plants of the cross of "Silver Mine" upon "Metropolitan," and the sample ear shown at 4 is more slender than the others in the plate. As elsewhere, the sweet grains stand noticeably above the starchy ones because the latter have become dented at their tips.

Plot 6 contained a set of plants in which the "Pride of Nishua" is the male parent of the cross and the "Stowell's Evergreen" is

the female. This introduces the yellow color and the ear selected from the photograph (No. 5) shows that two unit characters are represented, namely, the texture and the color of the grains, and the yellow and the dent being dominant are three-fourths in number and the white and the sweet, recessive, are one-fourth. In shape and length of grain, the ear shown is desirable.

Plot 7 produced a set of the blend plants of "Pride of Nishua" and the "Country Gentleman," but the sample ear (No. 6) does not show the zigzag character of the mother. This plot grew alongside of one of the "Voorhees Red" and some of the grains are marked with dark color from it. Probably, all mixing is thus marked and the original crosses in hand can be kept pure by casting out the grains showing the dark color, which may become the starting point of another line of breeding if so desired.

Plot 8 contained the "Pride" upon "Old Colony" and the sample ear is thick-set and taper-pointed with the grains irregularly placed; that all the ears are thus marked is doubted.

Plot 9 was among the latest to mature and suffered most from the uprooting that prevailed. The sample ear is long and somewhat like the "Silver Mine" upon the same sweet sort, "Metropolitan." This may prove to yield the best shape of ear in the whole set, but the irregular lines of grain are not indicative of good breeding.

Experiments with Corn upon Smock Land.

The Smock Land, recently received by Rutgers College through the generosity of Dr. J. C. Smock, was not in the best condition for breeding purposes, and the results upon the four acres assigned to the Botanical Department are far from conclusive in many respects. The area of a trifle more than four acres is in the form of a rectangle, somewhat midway of the whole thirty-five and a half acres and permitted of the growing of a breeding block of corn the whole two hundred feet across one end and small square plots of twenty-five hills along each side a hundred and fifty feet from the other similar patches and something more than this from the corresponding set of plots upon the opposite side of the area.

Some notes are given below upon the plantings upon the ten plots above located, and of an equal number alongside of each with other crosses of corn at a later date to reduce the mixing to the lowest terms possible with the adopted plan.

Plot 1. "Black Pop" upon "Country Gentleman" (137/19). White sweet grains. No plants produced ears.

Plot 2. Planted with white flint grains from same ears as for Plot 1. A few fair-sized ears resulted which varied from straight rowed and nearly white to zigzag ears with three-fourths of the grains dark purple.

Plot 3. Planted with "Black Pop" upon "Country Gentleman," pure black flint grains. The ears were too few and small to permit of an opinion of the test.

Plot 4. Planted with "Black Pop" upon "Country Gentleman," black sweet grains. Only two small ears were produced.

Plot 5. Planted with "Golden Bantam" upon "Ruby," purple grains and cob. Of the twenty-eight small ears, ten showed purple grain and cob; nine purple cob and two of these solid yellow, while nine showed no purple and all but one were solid yellow-grained.

Plot 6. Planted with same as No. 5, excepting that yellow grains from ear with purple cob were used. There were only seven small ears; four with purple cob and grains three-fourths yellow and one quite white and three were the same in grains but showed no purple in the cob.

Plot 7. Planted with white grains from same three ears as No. 6. Here the land was somewhat better and results are approximately a fair crop. Two ears purplish throughout, one-fourth yellow grains. Sixteen ears purplish throughout, all white grains. Six ears white throughout, cob, grains, etc., excepting that one had a few pink grains.

Plot 8. Planted with purple grains from ear with white cob and yellow grains. Four ears purple cob and grains, three-fourths yellow. Seven ears purple cob only with grains three-fourths yellow. Four ears no purple, grains three-fourths yellow.

Plot 9. Planted with yellow grains from ear with white cob. The crop was a failure, there being only three small ears; one with purple cob, purplish grains and three-fourths yellow; one

with white cob and purplish grains, three-fourths yellow and one with no purple, grains three-fourths yellow.

Plot 10. Planted with white grains from ear with white cob. Three ears showed purple tinge in grains, one ear white cob and solid yellow grains, three ears white cob and half the grains yellow. Six ears white cob and solid white grains.

The results with the "Golden Bantam-Ruby" cross are too meagre to warrant any conclusion along the line intended, namely, the nature of the purple color of cob and grain as regards the Mendelian law of inheritance.

In the second set of plantings upon Smock Land (June 20th) the following results were obtained:

Plot 1. Planted with Pop Corn upon "Black Mexican," selected rose-colored grains. Failed to fruit.

Plot 2. Planted with "Red Pop" upon "Black Mexican," sweet grains. Failed to fruit.

Plot 3. Planted with "Red Pop" upon "Black Mexican," flint grains. Failed to fruit.

Plot 4. Planted with "Golden Bantam" upon "Premier," yellow flinty grains. Failed to fruit.

Plot 5. Planted with "Golden Bantam" upon "Essex Early," yellow flinty grains. Failed to fruit.

Plot 6. Planted with "Malamo," pinkish grains. Failed to fruit. Plots 7–10 were planted with crosses of "Iowa Silver Mine," a large white western field corn, upon sweet varieties and similar crosses of "Pride of Nishua," a western yellow dent sort, but the plots all failed to produce results.

Reports of Testers of "Golden Bantam-Essex Early" Cross.

"Corn yellow, ears good length for size stalk, perfectly formed and sound, sweet and tender." "This corn came up fine, each stalk eared well, but most of the ears had very few grains. The quality of the grain was sweet and fine." "An excellent medium early corn. Plant of medium size, ears from eight to twelve rows, large kernels, delicious quality." "Very fine; plant tall and thrifty; grain tender and sweet. It was so good to eat that we could not resist eating all of it." "Came up well, and grew finely; quite sweet flavor." "Plant medium size, much larger than 'Golden Bantam' strong, vigorous grower, about five days

later than 'Bantam;" the ear is much larger than 'Bantam,' about 80% of the grains yellow, quality excellent, very sweet." "Flavor good, plant short, all ears early." "A promising cross; grains of good quality."

Breeding Plot of Sweet Corn— Smock Land.

The whole eastern end of the Smock Land was used for the breeding of sweet corn and three breeder rows extended lengthwise of the plot, that is, 200 feet and contained 50 hills each. These breeder rows are numbered 4, 8 and 12, and, at right angles to them, were the 50 rows each consisting of 12 hills as follows: 1, 2, 3, (Br.), 5, 6, 7, (Br.), 9, 10, 11, (Br.), 13, 14, 15. "Voorhees Red" occupied Row 4; "Mexican" long flint, Row 8, and yellow grains of "Golden Bantam-Stowell's Evergreen," Row 12.

Consideration of the Breeders.

Row 4, as previously stated, was planted with the "Voorhees Red" that crosses of it upon the fifty white sweet sorts might be secured. The "Voorhees" is a variety that originated by breeding the "Black Mexican" (a kind of very superior quality but having a dark color when ready for the table that is objectionable), upon the "Egyptian," another standard variety of the white group. The combination that was secured by selection has dark red mature grains and, at the time when ready for the table, are of an attractive pink color. With the hope of securing some combinations that might be an advance on either parent, it was particularly in mind to determine how this red sort would blend its color with the white varieties. Some have the opinion that it might not act as did its ancestor, the "Black Mexican," but instead the cross would show two shades of color, or possibly the result would be a black-colored grain. In other words. there was a twofold reason for making the "Voorhees" a breeder, namely, the improvement that might possibly come of it, and, secondly, the hope of light upon the behavior of a unique colored sort that resulted from a combination of a black and white parent.

Many dark colored grains have been secured upon a half of the varieties represented in the plot, and these show all degrees of discoloration, from a faint pink to grains that are practically black; many are variously clouded and mottled, the outcome of which is left for future crops.

The second breeder row was occupied with a long flint variety, brought by Director Voorhees from Mexico. The intent here was to secure an infusion of foreign "blood" into the standard sorts of sweet corn and, if possible, lengthen their grains and thereby increase the percentage of edible material in each ear. This "Mexican"—no other name for it being known—is a very tall growing sort with pink, hairy stalks of twice the average length of those surrounding them, and so late in blooming as to almost prohibit the securing of any crosses. It seems evident that, whatever the good points hoped for as to length and shape of grain, the slowness of growth may condemn at once any crosses that are obtained with it. For speed, and this is the *sine qua non* of early sweet corns, it is evident that to go north rather than south for breeders, is advisable. However, something may be in store from the very long "shoe-peg," "Mexican-American" crosses, into which quickness of growth may be bred, as the results may determine.

In the third breeder row were planted the yellow grains of a cross of "Golden Bantam" upon "Stowell's Evergreen" with the hope of getting crosses that would be better than either parent. Seeds of such combinations are secured from the ears of several of the white sorts.

It is seen that this open, free air breeding has been between fifty-three sorts but only sets with three of these are recognizable. The scheme rests upon the fact that a flint sort, the "Mexican" in this instance, marks itself by producing a flint grain whenever its pollen fertilizes a sweet grain. In a similar manner, the pollen carrying yellow impresses this color whenever it produces a grain upon an otherwise white ear. It is probable that the "Voorhees Red" has followed the same rule of the dominance of color over no color and the dark grains are all crosses with it. In short, all flint grains—and they are in this instance rare—show crosses of the "Mexican;" all yellow kernels are crosses of the "Bantam-Stowell," and all dark grains, a blending of the "Voorhees Red"

with the white sorts. Of course, the fifty white kinds have crossed much with each other, depending, possibly, upon time of blooming in most part, but experience teaches that among corns there may be affinities that account for some of the differences in this regard.

Conditions for this Crop.

The breeding plot was located upon land that had been recently acquired and was not in a high state of cultivation, and combined with this, was a season that was remarkable for its backwardness. The table of climatic conditions for the crop-growing months of April and May for the past nineteen years, given upon the last pages of this report, show that they were seventh in the amount of rainfall, nineteenth in the amount of heat (that is coldest) and thirteenth in the amount of sunshine.

Another discouraging feature in the making of this experiment was the unlimited number of crows, which a wood lot close by made it difficult to control, for the field is at the rear of the College Farm and a long distance from the other breeding grounds. The first planting was generally uprooted and the second one, only saved by use of various scarecrow devices. Worst of all, as the grains came into the milk stage, the plot was invaded and the tying of bags upon the ears was not sufficient to secure the crop.

EXPERIMENTS WITH TOMATOES.

A somewhat different field treatment than formerly was given to the tomatoes the present season. The hills were made four feet apart each way and the usual hand-tillage was almost entirely replaced by horse-culture. A test was made of growing two plants in a hill, in many instances, with good results. Both stakes and wire frames were also used for holding up the vines with marked success.

Old Varieties Grown the Present Season.

Only a few of the commercial sorts of tomatoes had a place in the breeding grounds, this limitation being due chiefly to lack of

space; they were as follows: "King Humbert" (64), "Magnus" (75), "Dwarf Stone" (123), "Dwarf Champion" (153), "Yellow Prince" (148), "Model" (163), "Red Pear" (179), "Red Plum" (180), and "Laycock" (213). Each of these was grown for some special purpose, in connection with the breeding work as, for example, the "King Humbert," "Red Pear," "Red Plum" and "Laycock" for their length of fruit and the "Magnus" for its coarse foliage and the "Stone" and "Champion" for their dwarf plants. The "Station Yellow" (210), a home creation, was grown for further study and also the "Oligosperm" (220), which is the "Giant" under a new name, which means few-seeded, and concerning this last a special treatment is given elsewhere.

Varieties Not Before Grown In the Gardens.

No. 221. *"Hummer."* This sort had stout plants that were late in bearing fruit which, while smooth, red and apple-shaped, were too variable and often too small to give satisfaction.

No. 222. *"Superb Salad."* The plants of this variety were medium sized and fairly early, but for a field crop the fruits were too small. It might serve as a forcing variety where medium-small fruits are desired.

No. 223. *"Red Rock."* The plants were medium-large and early, but the flattish fruits, often quite misshapen, did not fully please.

No. 224. *"Sunnybrook Special."* The plants were small and bore fruits of medium size, fairly early.

No. 225. *"Carter's Sunrise."* Plants were very long and spreading with a suggestion of the "peach" foliage. The fruits were small and in large clusters.

No. 226. *"Florida Special."* The plants were small, the fruits red, smooth, but too variable in size.

Notes Upon the Crosses.

The chief end sought in the breeding for the present season was the increase in the polar axis of the large-sized fruit, the hope be-

ing to get a tomato that would permit of more fine slices than the best now upon the market. From the lack of a better term, that of "goose-egg" has been used in connection with this ideal fruit. The long tomatoes (those that are of the shape of a date, but much larger) are practically worthless, because of the very limited number of the large seed cavities—usually two, and the consequent flabbiness of the fruit. To breed into these fruits, as illustrated by the "King Humbert" and the "plums" and "pears," an interior that is "meaty," having many small seed-cavities and surrounded with a thick wall giving a solid interior and smooth exterior, is one of the leading features of the work. Along with this goes a study of the nature of the plant in all its characters and the selection of types that give promise of being an advance upon the varieties now in vogue. The season's work indicates that some progress has been made toward the desired ends and while the quest goes on the immediate results in the form of desirable kinds will be furnished to the tomato growers of the State for a practical test.

The number of crossed plants was more than two thousand, and space does not permit in this report of giving more than a brief note upon some of the most promising, while the large majority can have nothing more than the field notes as made in the record book. In this book the crosses are given in the order of the record number of the male parent, that is, if No. 1, "Acme," is crossed upon several as "Arcadia" (No. 5) and "Bright and Early" (No. 14) and "Nolte's Earliest" (No. 94), such crosses come before those of "Bright and Early" upon "Acme," "Nolte's Earliest," etc.

A large majority of the crosses of the present season were compound, that is, a combination of two crosses. Thus, a set of plants that gave some promise for length of polar axis combined with other desirable qualities is booked (page 5) under the following numerals: 1/5///103/181//33/53. The single slanting (fraction) lines indicate the first crosses between the numbers they separate; thus, 1/5 shows that "Acme" (1) was crossed upon "Arcadia" (5); 33/53 indicates that "Earliana" (33) was crossed upon "Fortune" (53); next, 103/181, that is, "Ponderosa" (103) upon "Sumatra Fig" (181), was used as the polli-

nator for the "Earliana-Fortune" cross indicated by the double slanting lines and, finally, upon this combination the "Acme-Arcadia" cross was bred, as shown by the three slanting lines between it and the other portion of the combination. In this complicated breeding, two parents, namely, "Arcadia" and "Earliana" tend to make the resulting plants early, while the "Ponderosa" is excellent for a large percentage of flesh, many locules and few seeds, and the "Sumatra Fig" is designed to add length, because of its slender pear shape. As a result, the plants as a whole, showed desirable qualities in the length of the polar axis, the fine flesh and good interior generally, but they varied in this regard and in fact were, as to be expected, far from uniform. Seeds were saved from the choicest plant, and, furthermore, a fruit was secured from fertilization within the plant for further special study of the combination. In the midst of all this union of various sorts, the two colors, "red" and "pink," kept themselves quite distinct and were evenly divided between the two. The colors are among the most difficult of the tomato characters to blend.

"Crimson Cushion-Sumatra Fig" Cross (26/181).

This cross is mentioned not because of great worth the present season, but for its variability and possibility of producing something good in the future. There were two rows of plants, one from seeds of a red fruit and the other from a yellow tomato. The plants were all remarkable for their large size and great length. Of the four plants from the red fruit seed, one was a yellow "plum," one a long "apple" and two were flat like the large-fruited parent.

These latter plants showed remarkable variation in the fruit in the same cluster, as if the attempt was made to illustrate all the intergrades between the fruits of the two parents. All the plants from the yellow-fruited seed produced yellow tomatoes, which is according to rule if yellow is the recessive color. One plant had its fruits very flat and broad with many deep ribs, thus giving a new type for yellow tomatoes, but one that seems to be of no practical value. The fruits of the other plants were more acceptable as being of large size for a "plum" type of tomato.

"Dominion Day-South Jersey" Cross (29/119).

The second generation of this cross was grown and the results are so favorable that seed was saved extensively for purposes of trial outside of the Breeding Grounds. All the plants were uniformly early and prolific, and the fruits had a smooth apple shape, ripening evenly and cracking but little.

"Duke of York-Ivory Ball" Cross (32/175).

Seeds were used from a "white" fruit of this cross for 1906 for the test the present season. The plants were unusually large and spreading, and of the four plants one was a fine red in fruiting and three were pale lemon, the former bearing good-sized tomatoes, but all the latter had fruits of plum form and shape and too small for general use. The fruit of most interest, aside from the great size of plant, was the one with a color that agreed with neither parent, and, in fact, might have been mistaken for the sort called "Golden Nugget." The possibility of getting a very productive, long season "plum" of striking color led to the saving of seed for a further trial.

"Earliana-Freedom" Cross (33/54).

This was an early fruiting cross bearing red fruits of two types, namely, five plants with flat "Earliana" type and three of a handsome apple shape that did not crack. Seed of the latter type was saved.

"Earliana-Yellow Peach" Cross (33/186).

The plants were long and slender and showed unmistakably the "peach" foliage. One plant bore large yellow fruits that showed a new type of tomato that set people to guessing when first seen. The fruits were of large size, quite long, yellow and deeply ribbed, or fluted, thus resembling a small, scalloped squash, with a poor interior consisting of few large locules and,

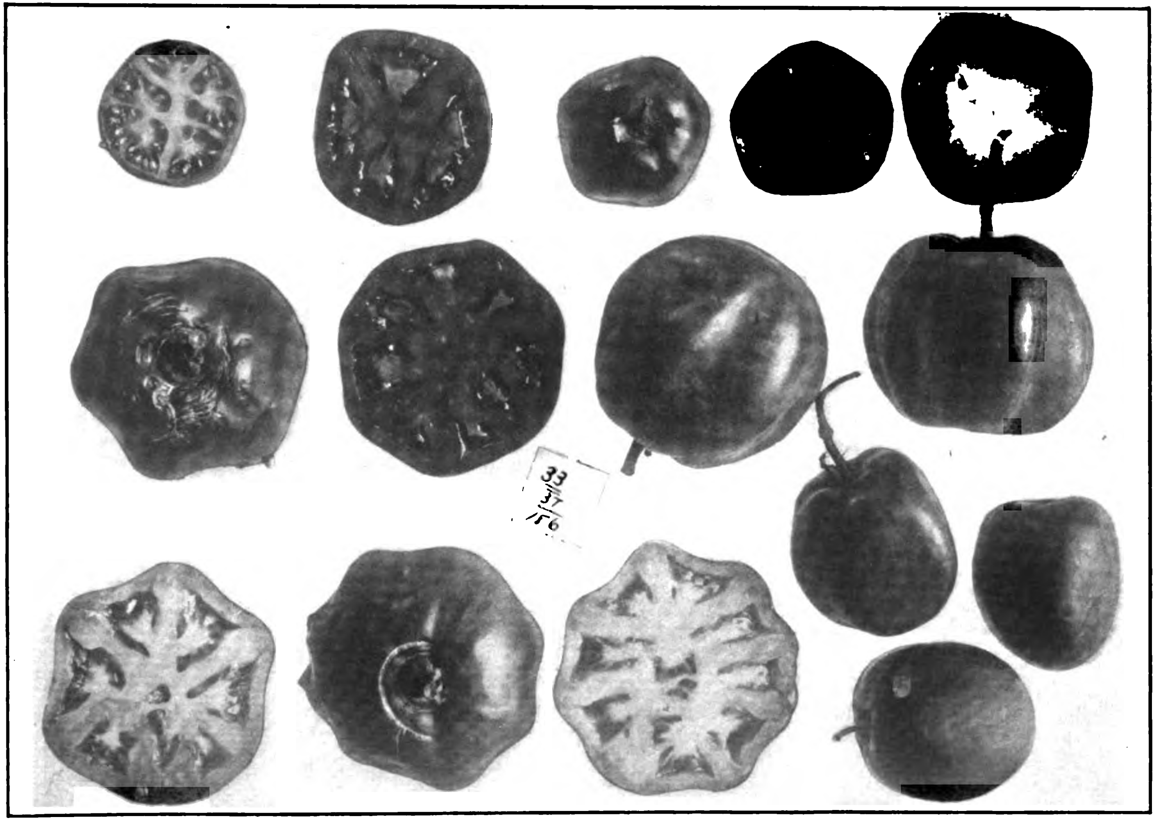


PLATE VII. *"Earliana-Yellow Peach" Tomato Crosses.* Side, end and interior views are shown of these peculiar fruits; the deeply corrugated nature of the large fruits is seen at the right of the middle and also in sectional view near the bottom of the engraving.

therefore, flabby; the corrugated exterior had the fuzz of the "peach." An attempt is made to show something of the peculiarities of the fruit of this giant "peach" in Plate VII., along with specimens from the other plants of the same set which were of the "peach" coating and texture but took the red color from the "Earliana." The card with record fraction is an inch square. Seed was saved of the giant-fruited type only that its progeny may be studied, without, however, much hope of valuable practical results.

"Earliana-Jewell" Cross (33/66).

In this cross, the fruits were quite uniform and showed some desirable length of the polar axis. On account of this and the early crops of fine fruits, seed was saved from hand-worked flowers.

"Earliana-Bright and Early" Cross (33/14).

The plants under this combination were of only medium size, but the fruits were bright red and fine apple shape and a quantity of seed was saved for possible distribution.

Some "Giant" Crosses.

The "Giant," as the name implies, is a variety that produces large plants and exceptionally large fruits but of the flat type often much ridged and with a solid core. A leading thought in using it is to develop a fine, firm, fleshy center in the cross and, at the same time, reduce the number of seeds. When worked upon the "Globe," the result is a variable fruit usually without great merit, but occasionally producing a long and pointed tomato of desirable size and showing a fine interior structure.

A combination of the "Giant" with "Globe," "Bright and Early," and "Nolte's Earliest" did not bring the desired shape, structure or earliness. Much better results were obtained with the quadruple cross of the "Giant," "Globe," "Earliana" and "Jewel," from which strong plants with long fruits combined with earliness

were secured. Practically the same results came from a cross in which "South Jersey" replaced "Earliana" in the combination last mentioned. This might be expected as "Earliana" and "South Jersey" are of the same type. The "Giant" with "Globe" and "Red Pear" gave a fine large "plum" that may develop something acceptable. This is a good instance of the "leveling power" of a small-fruited variety. There were many instances of this the present season as the "plum" and "pear" types were used upon a wide range of varieties to breed in the long polar axis of the fruit.

The "King Humbert" Crosses.

The "King Humbert," as a good representative of the long tomato but having little else of value as a high grade fruit, was represented the present season by forty-four crosses with it as the male parent and nearly as many more where it has been worked upon by other varieties. Speaking generally, the "Humbert" being of a small type, and, therefore, it is assumed, nearer to the wild condition, had the effect, as remarked above, of reducing the cross to the size and shape that goes under the name of "plum." When the combination represented three or more varieties "pulling against" the "Humbert," the size was reduced and the form, instead of being that of the plum, was nearer the apple as that term is used among tomatoes. This is true when "Fortune," "Acme" and "Arcadia" were in the combination. The cross of "Humbert" with a cross of "Giant Climbing" with "Ponderosa" gave large plants, one approaching the filiform type of foliage and with fruit of desirable length and size. In some of these sets of crosses, the plants were very variable and, while some were plum-shaped, others were irregular like the fruits common to the growers of tomatoes twenty-five years ago, and giving some suggestions as to the possible methods that have been in vogue in developing the more modern types of fruit.

The "Humbert" has been bred to the "Laycock," a variety procured from England last year because of its superior length. and the crosses this season have shown the long plum form, with the loose interior of the "Humbert" but little improved. Expe-

rience may teach that the desired end may be reached by a gradual approach instead of the attempt to strike averages between extremes.

The "Magnus" Crosses.

The "Magnus" variety of tomato has always shown good qualities of plant and fruit upon the Breeding Grounds, and the present season it entered into forty crosses. The apple shape of the fruit and its thick wall is often strongly impressed upon the cross as evidenced in "Magnerosa," which is a combination of this variety with the "Ponderosa."

Some good results have come from breeding the "Magnus" with the "Dwarf Champion" and with the "Yellow Prince." Two crossed plants this season had the coarse ("potato") foliage of the "Magnus" and the yellow fruit of the other parent. With "Alice Roosevelt," a fruit of fine size and length was obtained, and with a cross of "Giant-Globe" mingled with the last, a prolific and desirable combination was secured. One of the most hopeful of the crosses for the "goose-egg" type of large fruit was obtained from a combination which in the record book is expressed as follows, 75/103//103///103/181, which means that the cross of "Magnus" upon the "Ponderosa" (that is, "Magnerosa"), was next crossed upon the "Ponderosa" and this derivative cross was bred upon the cross of "Ponderosa" upon "Sumatra Fig." The "Ponderosa," a broad, meaty-fruited sort is represented three times and the medium long "Magnus" and the very long "Sumatra Fig" but once. From such a blending of the length and breadth at the same time, keeping the flesh in good condition, it is hoped to get an acceptable type of marketable tomato.

The "Stone" Crosses.

Some of the "Stone" crosses showed much to give encouragement to the breeder, thus the one with "Brinton's Best" was gratifying as a choice set of plants bearing large red fruits of apple shape. Seventeen such mature tomatoes were taken from

a single plant upon September 7th, each showing the center well broken up into small cavities. The seed was saved for distribution. The same cross, when bred to the "Magnerosa," gave prolific plants, some pink-fruited and others red, thus offering two styles of tomatoes as to color. A cross of the "Stone" with "Earliana" bred to a cross of "Giant" upon "Globe" produced some plants remarkable for their large smooth fruits.

The "Dwarf Stone" Crosses.

The "Dwarf Stone" was freely used because of its compact form of plant and solid fruit and some of the results were particularly desirable. New types of plants may be obtained, that is, the dwarf habit with various shapes and sizes of fruits that, while novel, may not be profitable. Thus, the combination with "Yellow Pear" gives a small, yellow-fruited dwarf plant that may have its place in some gardens.

The cross with "Enormous" last year attracted much attention upon the grounds, but this season it did not do as well. One of the best rows was the "Dwarf Stone-Ponderosa" cross in which much desirable length in the fruit was shown. That they were productive is evidenced by the statement in the record book that forty-seven ripe pink, apple-shaped fruits were gathered from a plant at one picking. It was not a dwarf, and seed was saved for further testing.

The most successful cross under this head, so far as the crop for the present season is concerned, is that of "Dwarf Stone" upon "Golden Queen," of which twenty plants were grown and by discarding the dwarfs in the seed box only standards (with one exception) were represented, and they were of fine vigor and satisfactory productiveness. The fruits were somewhat above the size desired by the market gardener—not a grave error, as it is easier to reduce than to increase the fruit—and they were of a bright ("cherry") red, smooth and, best of all, solid, with the core well broken by small seed cavities. A photograph was secured of some of the fruits, but not until the best of the crop had been seeded for distribution. The "Dwarf Stone-Extra Early Tree," contrary to the name, was too late.

"Gold Ball" Crosses.

The several crosses of the "Gold Ball" did not bring anything promising from the commercial standpoint, but some facts of interest in breeding were gathered. The "Gold Ball" is slow and it deeply influenced all its crosses in this respect, but its color fell into the category with other yellow-fruited tomatoes and gave one-quarter of its own color when bred with red and pink sorts. When crossed with "Ivory Ball," which is a kind with its small fruits of a pale shade of yellow, there was produced a variety of shades of lemon as though the yellow of the "Gold Ball" had been diluted by the "Ivory Ball."

The "Globe" Crosses.

The "Globe," a pink variety with fruit of a well-developed apple form and, therefore, with its polar axis long for the equatorial diameter, has been freely used in the attempts to get a fruit that has much greater proportional length. Of the combination with "Brinton's Best," there have been grown a row of both the pink and red-fruited kinds, and both were practically alike excepting the character of color, and from these superior plants seeds from the longest fruits have been saved with much hope of making substantial gains toward the end sought. One set of plants was grown from seeds saved from a long fruit of last year, and here the most encouragement is met with. In the row where the "Red Pear" "blood" has been added to the above cross, the effect was to drag the offspring down in size to a level of the "Pear" but the neck was rounded out and a "plum" resulted. In the case of the "Red Plum," added as above stated for "Pear," the fruit became larger than the latter and might well be said to be a small "apple." It remains to be seen in the quest for length and its desired accompaniments, whether the "Pear" is better than the "Plum."

The cross with the "Duke of York" was disappointing, for the irregularity in the fruit was augmented and the lateness of the crop proved an objectionable feature. With "Imperial," some

desired length was evident, but better results obtained with "Honor Bright," where the rich "cherry" color of fruit was combined with smoothness, great firmness and productiveness but no advance in length. In the many crosses with "Humbert," either alone or with one or more of several sorts, length was usually secured and from one plant where "Ponderosa" was thus added a long egg was in evidence. The "Globe-Magnus" has from the first shown good length and other desirable qualities in both the fine and coarse leaf types.

The "Red Currant" Hybrids.

The second generation from the blend of the "Red Currant" upon the "Dwarf Champion" was grown quite extensively the present season, and the formula for this set of plants is 177/154 B–1–5, B–5–9, etc. There were two general types of plants, namely those that were standard, that is, long, slender and wide-spreading, and the compact form that characterizes the dwarf plants. The latter are better because of their more restricted habit of growth, but are perhaps less fruitful. The tomatoes were borne in great numbers, and the clusters, adhering closely to the "Currant" type, were quite attractive with their numerous fruits of the size of cherries arranged in two rows along the common axis. It is likely that the output in pounds is as great from these hybrids as from ordinary large-fruited sorts, and the flavor of the tomatoes is so different as to make it possible for this combination to become somewhat popular when a "cherry" size can be employed. The types of foliage were shown in a plate in last year's report.

"Acme-Arcadia" "Red Currant-Ponderosa" Cross.

In this combination, there is first the union of the "Acme" and the "Arcadia" to induce more speed in maturing the fruit in the "Acme," the second union was between two species, namely, the small-fruited "Red Currant" and the enormous "Ponderosa" —and finally these two results were brought together. There

were only four plants in the set and they were all quite alike in their long slender type of stem and the fine foliage of the "Currant."

It is evident that the last named sort has a very great influence upon the progeny for, while with it represented as one among four, it asserted its peculiarities very strongly. The fruits were of the general forms, namely, a small plum and a fruit that had the same general shape of the "Ponderosa," it being broad, flat and somewhat ribbed, and showed many locules when sliced, and contained a fair percentage of medium-sized seeds. Those who saw it were inclined to call it "Baby Ponderosa," and this became its "nursery" name. The fruits were borne in clusters somewhat after the manner of the "Currant"—they were all pink in color like the "Ponderosa," but had the number of plants been large it is probable that the red of the "Currant" would have shown itself freely. The "Currant" fruits have a flavor that is different from the ordinary tomato, and the combination in question contained this in a marked degree, so that there is hope of getting a fruit of marketable size with a distinct and very agreeable flavor.

The "Oligosperm" Tomato, No. 220.

One of the results of the breeding together of the "Dwarf Champion" and "Golden Sunrise," in 1898, is a mutant that has been preserved from year to year under the garden name of "Giant." The original plant, grown in 1899, was remarkable for its great size and has certain peculiarities of foliage associated with it. Furthermore, the fruits were below the size naturally expected in the cross and quite limited in number, and contained almost no seeds, many being entirely seedless. The plants, in all the succeeding generations, have repeated closely the parent type, and from it has come a tomato that appears to merit specific distinction.

For several seasons, repeated attempts have been made to breed this tomato with the ordinary types, but until the present year the records show only failures. To what this lack of success is due is not clear to see. Those who have had this work in hand claim that there seems to be no lack of good, plump pollen. During

the present season, a greater effort than usual has been made to secure crosses, and out of many attempts three have given fruits, two of which had but one seed each and the other eight seeds, the latter being a cross with the "Red Pear."

This "Oligosperm" (meaning few seeds) is a yellow-fruited sort, getting the color, it is to be presumed, from the "Golden Sunrise" parent in the original cross. Coming as it did, in a block of plants all from the seeds of the same fruit and in which one-quarter were yellow, there is not much room for doubting that the plant in question arose in any other way than that indicated. It seems possible to consider it as a case in which a plant has taken on characteristics that are either new, or such a combination of old ones as to appear sufficiently marked to deserve a special mention in any complete classification of the tomatoes.

During the present season, a block of plants has been grown sufficient to provide for a quantity of seeds to be used in a limited distribution. As each fruit yields but, perhaps, a twentieth of the number borne by ordinary fruits, the packets, of course, can contain but few seeds. It is desired that those who are interested in the peculiarities of this tomato may have an opportunity of growing it. The practical trucker will not find it to his advantage to use it, for the plants are late in fruiting, and, as before stated, the tomatoes are small, rarely over two inches in diameter, but are of a peculiarly agreeable flavor. It is also important to test this tomato under other circumstances than those where it originated, as it is possible that a change of environment may induce some modification of advantage.

The chief hope of the "Sport" is that of breeding it to the ordinary sorts, with the thought of improving the quality of the latter and materially reducing their seediness.

Plate VIII. shows the "Oligosperm" fruits—a portion of a single picking—as grown the present season. In the center of the plate are two pairs of ripe fruits with portions of their stems, with one fruit above them showing the blossom end and one below with the calyx in view. Beneath the latter are the two halves of a fruit that resulted after the pollination with one of the ordi-

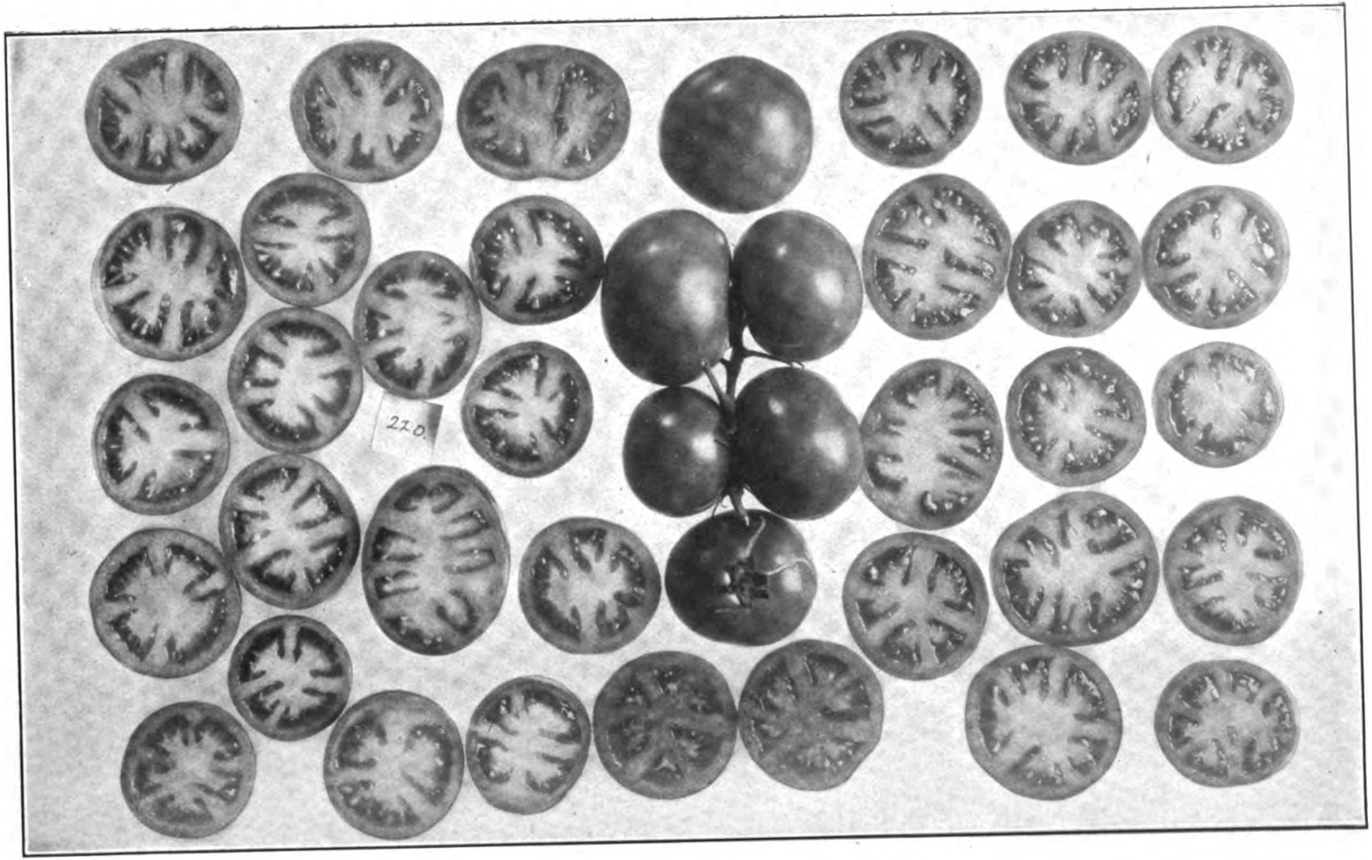


PLATE VIII. *The "Oligosperm" (few-seeded) Tomato.* Six whole tomatoes are shown in the middle of the group and, upon either side, halves of thirty-three fruits, some of which are entirely seedless.

nary sorts. It is entirely seedless, as is the rule when the flowers are hand-worked. The other portion of the plate shows one-half of each fruit, making in all thirty-nine tomatoes represented. A card an inch square is introduced to indicate size of the fruits and the number (220) it bears is that of this sort in the record books, and any results of crossing with it that may be affected.

A study of the slice-views will show that the number of seed cavities (locules) ranges from three to seven. The general absence of seeds gives a conspicuous pulp cavity, but because of the thick, but tender wall, the fruits are not flabby and keep well.

Tomatoes with Yellow Foliage.

The field of tomatoes has shown several plants with the characteristic yellow foliage. Such plants, while they have a sickly appearance, do not seem to be suffering from any disease. It is possible that the plants with this character do not mature their fruit quite as early as those with ordinary foliage of the same cross.

The following crosses showed the yellow foliage: "Freedom" upon the cross of "Honor Bright" upon "Freedom" (54//60/54), three out of the four plants, which was a large number, considering that "Honor Bright" is the variety that carries the yellow foliage. In the cross of "Honor Bright" upon "Honor Bright-Fortune" (60//60/53), there were only two out of ten plants with the yellow foliage. In another compound cross, as above, with "Frogmore" in place of "Freedom," the yellow plants were two out of five. In the cross of "Aristocrat" upon "Princess" (149/109), the first generation, the yellow plants were three yellow and one green and in the cross between the "Dwarf Champion " and "Dandy Dwarf" (153/158), all four plants showed the yellow color.

There is much to be done to satisfactorily determine the nature of the yellow foliage, but there are strong indications that it is a unit character (*unum*) with the green foliage as its opposite.

In the two present instances of the first generation, the yellow color shows in the blend in all the plants with one exception, but

the instances in all cases are too few to admit of any conclusions being drawn. As yet, not being impressed with the economic importance of the yellow foliage, the observations upon it have been entirely an aside.

This yellow foliage is not usually very noticeable until after the middle of the growing season, when it is so evident that the plants with it are easily seen among their green associates. A cursory study of the plant seems to lead to the impression that they have fewer of the glandular hairs than the ordinary foliage and through them there may be a way of reducing this disagreeable coating of rank-scented gummy substance.

The fruit of plants with yellow foliage behaves differently than that of the ordinary because of its losing its green color and being nearly white (lemon-white) for several days before it begins to take on the red or pink. In the row of "Aristocrat-Princess," two of the plants with the yellow foliage bore fruits that were yellow when ripe. This may be a novelty among tomatoes but the advantage of it to the grower is not at present apparent.

Increasing the Length of Large Tomato Fruits.

The commercial tomatoes, for convenience of classification, may be divided into small and large, the latter making up the ordinary marketable sorts, while the former (grown only in comparatively small quantities) are used for special purposes. The smallest, from its size of fruit and arrangement upon the stem, is known as the "Currant" and, next to it in size, is the "Cherry," followed by the "Plum" and the "Pear," all of which words are applied because they express quite closely the size and shape of the tomatoes. In the second group, to which the truly commercial sorts belong, the smallest may be spoken of as apple-shaped, especially when the surface is smooth, and this term admits of a wide range in the relative length of the polar axis for some apples are quite flat and others decidedly longer than broad.

To elongate the polar axis of the commercial sorts of tomatoes is desirable for purposes of household economy and to obtain a fruit that has a smooth, thick flesh at the end where, too

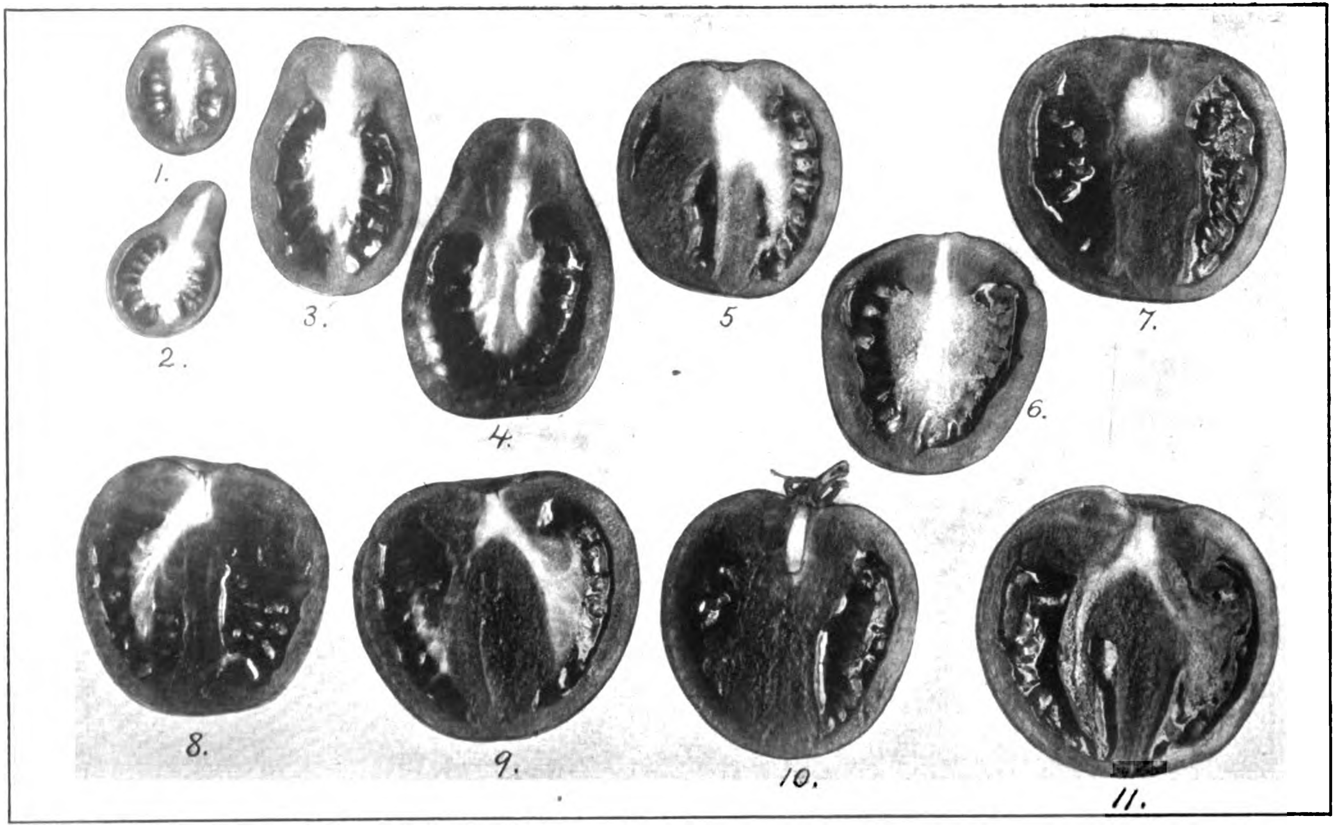


PLATE IX. *Tomatoes with Long Polar Axis.* From 1 to 4 are shown, in section, types of long small tomatoes as "plum" and "pear," and from 5 to 11 are similar views of fruits obtained by breeding for a long large fruit.

frequently, there is a navel structure of especial weakness because of its providing a means of access to germs of decay. Tomatoes, as now generally grown, lie upon the earth and the "blossom end," if rough with folds in the surface brings the pulp near to the skin and such are much more apt to rot than those that are uniformly thick-walled, pointed and guarded with a smooth surface.

Breeding for length, therefore, in the large-fruited tomatoes is between those that are long in the polar axis, as in the "plum" and "pear," and those sorts that will give breadth in the cross. The long, slender-fruited sorts, like those shown in the upper left-hand corner of Plate IX., as a rule have an objectionable interior, the seed cavities (locules) being few, often two, and of a type approaching probably the wild form. Such tomatoes are flabby, that is, the sides are not well filled out and the percentage of seeds and watery pulp is great and the solid flesh correspondingly small. The task of getting out of the fruits now known a marketably large fruit that has a long polar axis, far exceeding the equatorial diameter, and at the same time a satisfactory flesh is one to which the department is addressed. The "goose-egg" type is the desideratum in which the locules shall be many, the central core broken and the slice show throughout a "marbled" flesh of uniform rich color and but a single seed in each of the numerous cavities.

The hope is indulged that some progress is being made, as may be seen from an inspection of the fruits shown in longitudinal view in Plate IX. Original types are shown in the first four numbers; the others are all combinations. At 5, is a view of a fairly constant set of fruits that was obtained by a cross of "Ponderosa" upon "Sumatra Fig." The male is a widely known sort noted for its large size of fruit and has a low seed content. One of its chief defects is its flatness and irregularity, particularly at the blossom end where it is often broken and, in this respect, the two parents were nearly opposites, for the "Sumatra Fig," as the name suggests, is fig or pear-shaped, and the blossom end oval and smooth. The result of this cross has been a fruit that is a fair blend of the two in size and shape, and when, by

further breeding with the "Ponderosa," the size is increased, a long fruit of much merit may be expected.

At 6 is a combination of the "King Humbert" with "Fortune," the former being shown at 4 while the "Fortune" is a good apple-shaped sort. The cross shows a fruit that is not unlike the one previously mentioned but averages somewhat longer and larger.

The fruit at 7 is one of a compound cross, in which the "Ponderosa" figures twice, the "Magnus" twice and the "Globe" once, and is represented by the following fraction: 75/103//103-///194/75. Here again, the "Ponderosa" (103) is used from its good qualities of flesh with minimum seediness, while both the "Magnus" (75) and the "Globe" (194) are employed to elongate the fruit slowly, at the same time retaining an interior that is of merit. It is not known what the ancestry of the "Magnus" and "Globe" may be, but presumably there is "blood," in one or both, of a so-called long-type.

From another direction, a set of plants was obtained bearing fruits of the form shown at 8; it is not unlike the last but much earlier in its time of fruiting, a point that must not be overlooked in the production of any type of fruit. In the cross, the male parent is "Earliana" and its mate the "Jewel.' For forcing, when in midwinter medium-sized fruits are acceptable (if not preferred), this cross may prove desirable, for along with the fine shape and contents, it is quick maturing and productive.

The fruit at 9 is the result of a cross between the "Globe" and the "Ponderosa" and in many points is already a most desirable type of tomato, thick-walled, few-seeded, rich, and pink-fleshed; it gives much promise.

One of the nearest approaches to the "goose-egg" is a case in which none of the long sorts (so-called) played any direct part, for it is the derivative cross between "Magnus" and "Ponderosa," expressed by the fraction, 75/103//103—and, therefore, the large-fruited "Ponderosa" is very largely represented. At 10 is shown an average sample of the fruits of the combination in which the egg-shape is well seen, but in a fruit with several locules and a flesh that is solid and most desirable in texture and uniform color.

At 11 is a specimen of a derivative cross in which three varieties are combined as follows: 75/103//103///103//103/181. In addition to the lengthening influence of the "Magnus," there is the "Sumatra Fig" at work, diluted (so to say) by the "Ponderosa" "blood" before it is brought into combination with the "Magnus," which is likewise blended with the "Ponderosa."

Tomatoes Offered for Trial.

Last spring, only three crosses of the tomatoes were sent out for practical testing and one of these, the "Magnerosa," only in special cases because it was widely disseminated the year before. Twenty-five plants of it were grown upon the Home Grounds and the previous record was maintained for a superior midseason variety producing solid, smooth, pink fruits.

The following notes from the growers who received seed this season confirms all that has been previously said. Those who are growing it from the seed from their own crops of the previous year have not been asked to report.

Reports from Testers for "Magnerosa" Tomato.

"In good soil and properly irrigated, the result is very satisfactory. Plant very vigorous and productive, fruit, generally speaking, uniform in size, not quite as large as 'Ponderosa,' but better shape, being smooth and nearly round." "The 'Magnerosa' made a strong growth, and the fruit borne on the vines is smoother than that borne on 'Ponderosa' vines—also it seems to be more prolific." "Fruit solid and good quality, color right up to stem, smooth and uniform in shape, which approaches the spherical, color red, toned with lilac pink. The vines average from two to five feet in length and bushy in proportion, well set with fruit." "Plants were very large, having five or six branches very well filled with fruit, these were started under glass. The fruit is very uniform in shape." "This has proved itself to be a very good kind of tomato; it has a good flavor, it is large, smooth and a color which will make it sell. The foliage is a good green of good growth and free from all blights." "Strong growth, well fruited." "Vines very vigorous, large and productive." "'Magnerosa' is doing well." "Is a very vigorous

grower and I consider it productive, light pink in color, very solid and sweet, and under these conditions a very good addition to the garden." "Fruit small but shows up well, and plant sturdy and strong." "Tomato quite productive, medium size, fair, round, smooth, medium early." "A very nice and good tomato, the color is a bright red, the shape is round, the plant is a healthy, strong grower and very productive. I consider it a very good variety." "Free in growth, prolific in bearing, good flavor." "Good quality and very solid." "The tomato you sent me was an entire success, plants very large and vigorous; fruit very productive with a delicious flavor." "I am very much pleased with this variety." "The tomatoes were grand, the bushes were about five feet high, the leaves are large and a very dark green, and they weighed about a half a pound and they were fleshy." "Fine flavor." "The fruits are perfect in color and form, ripening to the stem. The plant is open, good size." "Fruit large but irregular." "The plant is very large and productive and the fruit is nearly uniform in size; a palatable flavor." "Tomato is large." "This tomato is excellent for the table. Fruit generally uniform in size and color. Number of fruits to a vine 22 to 30. This tomato is very fleshy and full and very good flavor." "They are a vigorous grower and the present indications are that they will yield about with the "Stone." "In quality my wife says they are just grand." "Vines vigorous, good-sized fruits. An excellent pink sort, solid, like 'Ponderosa,' but smooth and, therefore, a great improvement over the latter. Prolific, as I counted as high as seven good-sized tomatoes in a single cluster." "Size medium, plant vigorous and productive, shape good, color bright red, uniformly good." "Tomatoes vigorous, medium size and very solid. The best feature of this tomato I consider is its solidity." "Tomatoes are nice and smooth, good bearers." "The vines are strong and healthy and have a fair set of fruit." "Very productive and the best flavor and sweetest tomato I have ever had." "The 'Magnerosa' tomato is all right; very productive, good size and smooth and very highly colored; plant made a vigorous growth during a dry season."

Reports from Testers for "Marvelosa" Tomato.

"Plants are very large and are full of green fruit. Good shape." "Notwithstanding the very dry season they have made vigorous growth, and are of good size, foliage of rich color." "The plants were good size and growth. Fruit quite uniform

and very solid." "In spite of the unfavorable season, tomato vines seem quite vigorous." "This is better than its 'Ponderosa' parent, is a better shape, ripens to stem end, is very prolific, no acid, and is fine in every way." "The 'Marvelosa' tomato is a fine color." "Very satisfactory, making rapid growth and setting plenty of fruit to each vine, medium size, varying little in size on all vines planted." "Plant vigorous and prolific." "Plants strong and thrifty, bear well, fruit mostly regular in shape and solid with very little core. Has stood the dry weather better than other kinds, not showing any tendency to rot as other kinds have done." "The plant entirely covers the ground, planted four by four feet. Most of the plants have very large tomatoes, mostly red, with an occasional pink, the quality is very good and quite productive." "A good yielder, better than 'Magnerosa.'" "Tomatoes have been of good size, light red in color, solid meat." "Plants are large and vigorous, very productive, fruit large." "Very good scarlet sort. The small to medium-sized fruits smooth and handsome. Vines very vigorous, good yielder." "These tomatoes show an excellent growth, the plant does not spread out much, but has a good stalk and is very prolific." "Am well pleased with this. Plants vigorous. Trained to two stems, now four to five feet tall. Foliage abundant, healthy. Fruits large, regular, smooth, well-formed, meaty, bright red. No rot and but little cracking. Vines are bearing wonderfully. I never saw anything like it before in yield and average size of fruit." "Plants vigorous. Fruit smooth and round." "This tomato is very fleshy, best of flavor, very few seeds, plant strong, vigorous growth, beautiful color, a good bearer, solid and delicious fruit. Am more than pleased." "Fruit is of good size and shape and has a very fine flavor. Some specimens have a green core in interior. Vines are very productive and of large size, with heavy foliage." "Plants vigorous and well filled with fruit of good shape." "Very good, solid and good flavor. Color pink, medium early, smooth and fair size, very prolific." "The tomatoes are very fine." "Good growing plants. Desirable." "Plant large, grows three to four feet long without support. Productive. First fruits very large and not very smooth. Some nearly six inches across. Bulk of the fruit large, uniform, smooth and colors all over a bright red. Very solid and of excellent quality. Ripens quite as soon as the 'Stone.'" "Tomatoes very fine, strong and vigorous vines, well set with fruit. A very desirable tomato." "Plants are large and vigorous. Color of fruit a bright red, meaty, and of excellent quality." "Medium size, shape almost round, very handsome medium plant

and producer." "Large size, some weighing a pound each. Plants thrifty growers." "Tomatoes from this seed were highly satisfactory. Good shape, no core or hard part, color and size good." "Very productive and bore good, firm tomatoes of medium size." "All plants were thrifty. Some gave us very large plants and fruit; very solid and perfectly smooth and of extra fine eating quality." "Healthy foliage, prolific bearer, having two kinds of fruit—a large red on most plants and a small pink on a few others. Quality very good."

Reports from Testers for "Crimson Cushion-Marvel" Tomato.

"An excellent table variety." "This tomato cross will no doubt be a fine tomato. Its vines are fairly vigorous, fruits, in cluster three to five, good size, shape and uniform." "Plants large, vigorous, very shapely, productive, fruit medium in size, very meaty, deep pink in color." "A fine variety, large, vigorous growth, very productive. Fruit, medium to large and solid, very uniform, rich red." "Vines vigorous, good shape." "This is a gem; about the finest tomato I ever grew. Very vigorous, long prolific bearer of good-sized, unusually smooth, solid fruits. It will be hard to beat." "Vines healthy looking." "Part of plants potato leaf, and part regular tomato foliage. Plants with regular tomato foliage, large and vigorous. Plants with potato leaf a rank grower, but not as large and more upright. Fruit medium in size, very solid, nearly round and perfectly smooth, with but very little acid; the sweetest I ever tasted; all of same shape and size." "Vines very thrifty, fruit fair size." "Plants vigorous growers, foliage healthy." "Large, vigorous plants, and fruits round, uniform and of a fine scarlet in color." "Fruits smooth, uniform, medium size, good quality, resembling 'Crimson Cushion' tomato, good bearer, an excellent general purpose tomato." "The tomatoes were large and the bushes were very productive." "Fair sized plant; some fruits were large, color red, extraordinarily prolific." "Bore well and fairly good quality."

The Interior of the Tomato.

The interior of a tomato fruit as here considered embraces all within the skin and may be divided into (1) the flesh, (2) pulp, and (3) seeds. Under the first heading is included (a) the rind, or covering outside of the seed cavities (locules), (b) the par-

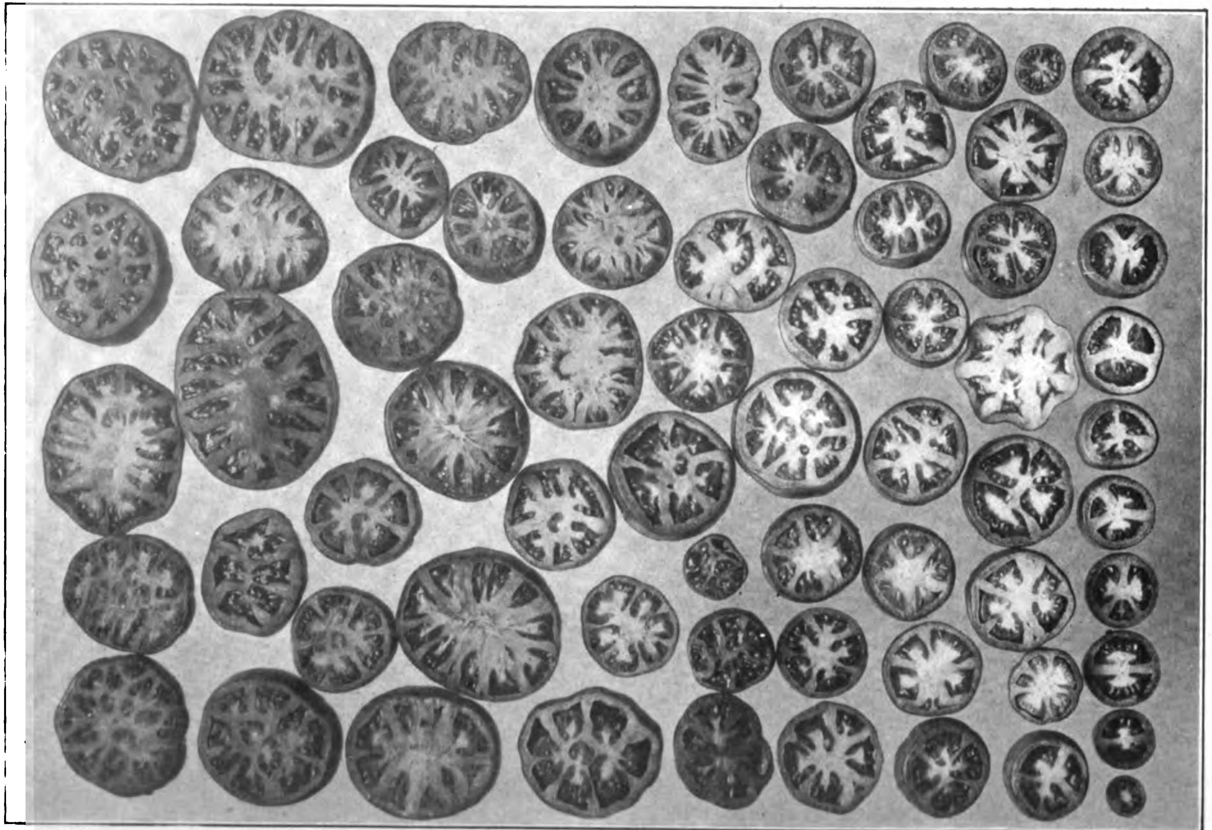


PLATE X. *Sections of Tomato Fruits.* A group of fruits in section through equatorial diameter, showing something of the probable stages in the development of the fruits upon the left from those shown upon the right hand.

titions between the locules, (c) the connections between the latter and the seeds, botanically known as the placentæ. The second primary group is well defined and does not admit of further division, but is subject to remarkable variations in the evolution of the modern, highly modified fruits. This pulp is the soft part that surrounds the seeds and may be easily squeezed out of the locules along with their contents, namely, the seeds which constitute the third main division of the fruit.

The rind, the division walls and the placentae, taken collectively as the flesh of the tomato, is the portion sought for by the housewife. A chief difference between the solid and desirable fruit and the flabby one is the large percentage of the flesh. Compare, for example, the fruits as shown in slice view in the row at the right and the one at the left in Plate X.; the latter are, of course, of larger size, and represent the type that is sought for in present-day tomatoes. Instead of the two or three large locules that are characteristic, presumably, of the fruits of the species in its wild state, the seed-cavities are numerous, each one comparatively small, and surrounded with thick, firm partitions, bearing uniformly the rich color of the variety, and having no hard green central core so often met with in the older types of tomatoes. The beauty of the slices of the highly-bred fruits, as they are served, bespeak a great future for this modern accession to the vegetable garden. A large slice, displaying sufficient firmness to handle well, with its highly-colored flesh free from all semblance of hard, green spots, and interspersed throughout from center to circumference with many small locules, each with one or but few seeds, is an object that is tempting in the extreme. Should some of the slices be cherry red, and others orange-yellow, and distinguishable in the high flavor of their contents, the dish becomes all the more attractive. The subject deserves the use of colored plates to do feeble justice to the richness of hues of these high reaches of the art of the tomato breeder.

But it is not only the contents of the fruits that are in contrast between the samples upon the extreme right and left hand in the plate. It goes without saying that here, as elsewhere, there is a size below which it is not acceptable, and the universal verdict

upon many present varieties is their smallness. The error may be in the opposite extreme, and the kind is rejected because of its over-sized fruits. These objectionable extremes have been kept in mind, and the giant and the dwarf in fruit are interesting, chiefly as marking the range. Therefore, into the set of slices shown, none of the very largest have been introduced, and samples of the "Currant" are likewise lacking.

Beginning upon the outside, the first subject for consideration is the skin. Ordinarily, this is a tough layer of tissue that serves well the purpose of protecting the tender inner parts from the many enemies from without. A defect here is in its tendency to crack, which frequently should not be ascribed so much to the skin as the flesh beneath, as it is due largely to an unevenness in ripening. This is often met with in the early, flat form of fruit, where the shoulder or stem end of the fruit is the last to remain green, and cracks occur in the flesh between the ripe and ripening portion, and often in somewhat concentric lines as the maturing progresses. At the blossom end, the skin often is poorly backed up by a good rind, and breaks occur and decay ensues. Fruits with a smooth blossom end, and well supplied with a thick rind, are the least liable to "go down." The tomato fruit is quite susceptible to influence from the weather, and, during a wet spell. are apt to fill with water, and, if the skin is too weak, the fruit cracks and is soon worthless. For this reason, a firm skin and rind is desirable, and such quality helps to exclude the germs that seem ever ready to attack the fruits. As ordinarily the skin is removed before the fruit is served, any addition to its firmness may not prove objectionable, and some attention might well be paid to this side of the question of improved tomatoes by the breeder.

When it comes to the rind, the next subject to command attention in passing inward from the skin, it is evident that firmness here must not go beyond a well-established limit. Above all things, it must be edible, and to this end consistency and flavor are nearly everything. The flesh of the outer wall, in other words, needs to be uniformly fine in texture and color, and thickness here is perhaps a leading desideratum. If the wall is thick and sufficiently firm (within the limit of tenderness), the fruit

will present a uniform surface upon the outside, provided the locules are many and, therefore, small. A large "pear" (even though the wall is quite thick, but having but two seed-cavities) will be pressed out of shape in the basket, and when the rind is thin, as is usually the case, the fruit is flabby while still upon the plant. There is much to be done in improving the rind among standard sorts of tomatoes. As the eye runs over the display of slices in the Plate, several fruits are seen that have the rind so thin that the tomato—still green, as all the fruits were purposely immature when used for the photograph—is more or less corrugated. "Rough," or angular tomatoes, as a rule are defective in this respect because of a lack of a proper thickness and texture of rind.

The partitions (dissepiments) between the locules are not as a rule all that one desires. To say that they ought to agree in texture, thickness and color with those qualities of the outer wall is to very closely cover the desired points. In the old type of fruits, shown upon the left hand of the Plate, the partitions, although very limited in number, are of good thickness for fruits with many seed-cavities, but they make up only a small percentage of the contents of the tomatoes, having only two or three locules. The fruits upon the right indicate that, so far as the partitions are concerned, they are approaching the ideal.

A consideration of the walls of the fruit, in a certain sense, disposes of that of the pulp and seeds, for when the flesh is developed to its desired amount, the locules will be necessarily many and small. In the evolution of the tomato fruit, there was the increase in size, accompanied with that of the number of the partitions, thus adding to the locules. The seeds decreased relatively, but not absolutely. A large "Ponderosa" fruit has many times less seeds per pound of flesh than the "Currant" or "Cherry," but of course many more than any one of these small tomatoes. After the locules reached five or six, there comes a broadening of the fruit, the core being more prominent than before. Several such fruits are shown; while the size was augmented, the roughness of the exterior increased, and also a corresponding amount of waste.

Perhaps the most desirable advance was made when the core became broken and the seed-cavities were not all arranged around or along a common center. The reader may be rewarded in a search for the slices in which there is no distinct core, but, instead, one or more locules in the center of the fruit. Once this important end was reached in the development of the tomato, the way became clear for the development of fruits in which the core, as such, does not exist and flesh and locules are interspersed as shown in the slices at the right hand of the Plate. The reader must not conclude that any one fruit is the type of all the others upon the same plant. This may be true for the old-time and simple types but the highly developed modern kinds will require much further attention before that desired end is reached.

A Preliminary Classification for Tomatoes.

There are certain characters among tomatoes that are not easily disturbed in the breeding of widely different sorts, and from their behavior may be considered Mendelian. Thus, as regards the whole plant, there are two types, namely, the "standard" and the "dwarf" and when these two are united the offspring in the first generation after the blend show one-quarter of the dwarf type. Again, should a fine-leaved and a coarse- ("potato")-leaved variety be bred together the result is a quarter of the coarse-leaved plants following immediately upon the blend generation. In one set of crosses (the "Dwarf Champion" upon "Magnus") where the two characters above considered are involved the following results were obtained:

Standard,	fine-leaved	plants,	49;	theoretical,	45.
"	coarse-leaved	"	16;	"	15.
Dwarf,	fine-leaved	"	13;	"	15.
"	coarse-leaved	"	7;	"	5.

In this instance, the "Champion" was "fine-leaved" and "dwarf," that is, of the two unit characters (*una*) in question one was dominant, namely, the foliage type and the other, the size of the plant, was recessive, that is, excluded when its antagonistic char-

acter, the large type of plant, is present. In a similar manner, the "Magnus" carries a recessive character (the coarse foliage) and a dominant one as to its size of plant.

There are two types of foliage as to its color, namely, the ordinary green, which seems to be a dominant character, and a peculiar sickly yellow that conforms to the Mendelian law so far as this type of tomato foliage has been studied by the writer. As each of these antagonistic, or mutually exclusive, characters act independently, it is found that when three sets are involved as (1) size of plant, (2) shape of leaf and (3) color of foliage, the theoretical numbers will be as follows:

Standard,	fine-leaved,	green	foliage,	27
"	" "	yellow	"	9
"	coarse-leaved,	green	"	9
"	" "	yellow	"	3
Dwarf,	fine-leaved,	green	"	9
"	" "	yellow	"	3
"	coarse-leaved,	green	"	3
"	" "	yellow	"	1
				64

The practical test of this theoretical table in its entirety for tomatoes has not been made by the writer but opportunity may offer in the near future.

Turning now to the color of the fruits there are at least three una that may be considered, namely, the "red," the "pink" and the "yellow," all three of which are far from true to the popular names given to them, for the "red" is more orange than red, the "pinks" about midway between orange and red, while the "yellows" contain much orange, but for the present purpose they may be treated as distinct colors in reference to tomatoes.

It is found that when the "red" and "yellow" are bred together the red is dominant and, as a result, the number of yellow-fruited plants in the first generation after the blend approximates 25 per cent. The same result obtains when "pink" replaces the "red" in the above cross, thus showing that the "yellow" is recessive to both the "red" and "pink." When the "red" and "pink" are bred together, the results have not been so sharply defined, that is, the "red" is less evidently the dominant and with this set of crosses more study is desired.

To this list of una, it is probable that further study will demonstrate that the smoothness and the hairiness of the fruit may be added, that is, in the various crosses with the "peach" tomato the fuzz of the latter kind appeared in numbers to suggest that it is a recessive unum.

It is too soon to decide how much weight should be placed upon mere size of fruit as a unum. It is probably true, however, that two general sizes may be employed as a final factor in a scheme of classification that is here offered:

- **A. Standard.**
  - **B. Fine leaved.**
    - **C. Green foliage.**
      - **D. Red fruit.**
        - **E. Smooth fruit.**
          - **F. Large fruit.**
          - **F. F. Small fruit.**
        - **E. E. Hairy fruit.**
      - **D. D. Yellow fruit.**
      - **D. D. D. Pink fruit.**
    - **C. C. Yellow foliage.**
  - **B. B. Coarse leaved.**
- **A. A. Dwarf.**

In the above scheme, the six chief points are given only for the first head under each division, thus, the same sub-divisions obtain for "dwarf" as for "standard," for "coarse"-leaf as for "fine" leaf, etc. In other words, for example, there are red-fruited varieties, theoretically at least, for both "green" and "yellow" foliage, of both "fine" and "coarse"-leaved, and of both "standard" and "dwarf" plants.

Many of the standard varieties could be arranged under this scheme, but for some of the headings the representatives are lacking. This is particularly true of the yellow foliage (subdivision C. C.) and the hairy fruit (E. E.), but should one desire to do so, the way is clear for filling up the deficiencies in the scheme, but usually they would result in plants and products that would not appeal to the practical tomato grower; thus, one might make a dwarf, coarse-leaved, yellow-foliaged and yellow-fruited, hairy tomato of small size that, while interesting as a novel combination of qualities, would not be sought for as a big seller.

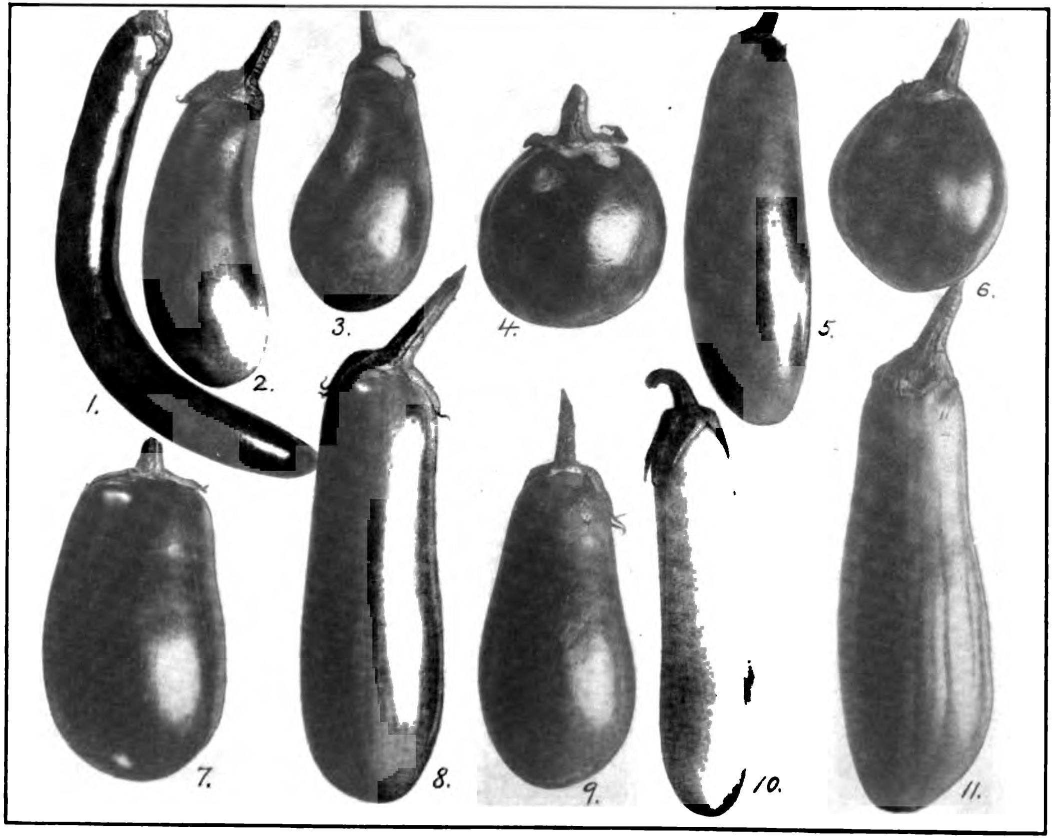


PLATE XI. *Eggplant Crosses.* The parents are as follows: 1, "Black Snake;" 3, "Dwarf Purple;" 4, "Pekin;" 7, "Jersey Belle;" 10, "Long White," and the blends located near parents at 2, 5, 6, 8, 9 and 11

EXPERIMENTS WITH EGGPLANTS.

A somewhat larger space than usual was given upon the Home Grounds to the experiments with eggplants. This was due to the long list of crosses under consideration, and the continuation of the work with the hybrids between the "American" and "Chinese" species that rapidly expands with the years. Only one commercial variety was added to the list, namely: "Round White," which takes the record number 29 in the many crosses that appear successful with it.

A Study of Blend Fruits in Eggplants.

The blend plants of the several crosses of eggplants have shown remarkable uniformity; thus, two rows of these were in quite striking contrast with those alongside of the first generation after the blend. This is as one expects after some experience in the breeding of plants, but perhaps nowhere else in the truck garden is this better illustrated. By crossing two dissimilar types, for example the "Black Snake" and "Dwarf Purple," the former a tall standard and the latter a true dwarf, a uniform set of semi-dwarfs is obtained that blooms profusely and bears an abundance of fruit. A fruit of the "Black Snake" is given at 1 in Plate XI., and is seen to be long, slender and bent (often to more than a right angle). This kind is too small for practical purposes, and the plants are not sufficiently productive to make them worthy of a place in the home garden, except as a curiosity. The "Dwarf Purple" fruit is shown at 3, and is an early sort, but the fruits are too small for market purposes. At 2 is shown a sample fruit of the blend, which is a thorough union of those next to it. Thus, the "Black Snake" is practically spineless, has a calyx that is green, tinged with purple, and the fruit flesh beneath it is a pale green, the body of the "egg" being purplish green, somewhat striped, while the "Dwarf Purple" has a solid dark, almost velvety, purple upon the fruit, calyx and stem, but is nearly white beneath the calyx; this is shown in the plate as one of the calyx lobes was removed just before the picture was

taken. The blend fruit is decidedly curved, but not as much so as the male parent; the color is a combination of the two parents, thus giving an indistinct showing of stripes in which green plays a much disguised part, while the calyx is like the "Black Snake" in some features, but of a purple approaching the mother. The color of the fruit under the calyx is less white than the one and more green than the other parent. These items are dwelt upon to impress the fact that the union of two dissimilar sorts in its first offspring, the blend, is an almost amusing reflection of both parents, the analogue of which is seen in the blending met with in human families.

At 4 is a small fruit of the "Black Pekin," characterized by being practically round, of a dark purple, and, like the "Dwarf Purple," nearly white beneath the calyx lobes, as indicated in the engraving. The plants are tall and purple in stem and leaf. When this variety is bred to the "Black Snake," the first season shows plants of great uniformity and fruits, as at 5. This fruit is nearly straight, and of considerable length and size, showing that from the economic standpoint this cross may exceed in value the one that was last considered. As the parents are both tall and slender, the offspring is likewise of the same class, holding its long pendent fruits often a foot above the ground, which is a desirable feature when the matter of decay is considered. The markings of this blend are all a union of those of the parents, with the addition that the first year is characterized by a profuse bloom and a large yield of fruits.

The fruit at 6 is from a blend plant of the "Black Pekin" upon "Dwarf Purple," that is, a combination of those whose fruits are shown at 4 and 3—the male being given first as always in mentioning a cross. Here the great differences are in the plants themselves, for one is a tall type and the other a dwarf and, as a result, a medium-sized plant is obtained of considerable merit. The fruit is neither a sphere as in the "Black Pekin" nor a long "pear" produced by the "Dwarf Purple," but is somewhat oval and not handsome with a stem that is as stout as that of the "Pekin."

At 7 is shown a small sample of the "Jersey Belle," a variety produced some years since by breeding together the "Long Pur-

ple" and the New York Improved," and is here introduced as a parent in a cross upon the "Black Snake" shown at 8. This combination results in a medium tall plant with a blending of the qualities of the two parents as fully in all respects as they are shown for the fruit. Bear in mind that the two end fruits, one over the other, are the parent types of the one shown at 8. The curvature of the "Black Snake" has been extracted entirely in the instance illustrated but some of the fruits show a bend that might be expected. In the blend fruit there is to be seen both the fine purple of the "Jersey Belle" and the obscure green striping of the "Black Snake." This is shown in the photograph (lost in the engraving) and is highly interesting to the breeder but possibly might be objected to by the judge of vegetables at the horticultural shows. For the home garden, this cross is recommended because it is prolific, the plants are tall and the fruits are held up from the soil; it is practically spineless and the shape and size are very desirable for economic handling and preparation for and serving at the table.

The "Jersey Belle" upon "Dwarf Purple" blend fruit is shown at 9, and here again the greater differences are in the plants themselves, for one parent is a medium tall type and the other a dwarf. The fruit is of a larger size than the "Dwarf Purple" and usually without the curve that is often seen in the parent. An interesting blend of characters is seen in the color of the fruit flesh beneath the calyx; in the "Jersey Belle," the color is practically the same all over the fruit clear up to the insertion of the stem, while, as pointed out before, that of the "Dwarf Purple" beneath the calyx is white. In the blend the color is a light pink as is indicated in the photograph for the portion exposed by the removal of the calyx lobe. It may be added here that when the fruit surface is exposed, as in these instances, the color soon develops there as elsewhere on the fruit.

At 10 is shown a specimen fruit of the "Long White"; this is a slender, nearly straight fruit with a pale green color and is introduced here as one of the parents of the blend fruit shown at 11, namely, "Long White" upon "Black Snake." It is interesting as being an instance where the combination increases the size, but probably the fruit shown is above the average in bulk. Both the

parents are long and the blend is somewhat midway, but the surface coloring is a close reproduction of the "Black Snake," as the other parent has no color value to change it in the blend but in the next generation one-quarter will probably be white.

"Long White" Upon "New York Improved" (11/18).

The above-named cross has proved to be unusually attractive and now, five years after it was made, the results warrant offering the seeds of two selections from this one combination under special names for further trials by those who may wish to grow them.

The "Ivory."

The male parent in this cross is a variety with plants of medium size, having green stems and leaves and the flowers showing only a small amount of the purple common to the ordinary sorts, while the fruits are long, slender, somewhat curved and of a greenish white color. Upon the other hand, the female parent belongs to the group of "medium tall' varieties with dark stems and foliage and large, oval, purple fruits.

The blend plants of the cross, grown direct from the seed from the fruit resulting from the hand-worked flower, gave a uniform lot of plants in which the color of the mother was dominant in plant and fruit. Seed from these plants, fertilized by hand within the cross, gave a mixed lot of plants, some of which were smaller than others and the stems and leaves of a quarter of them were lacking in the purple color and produced pale flowers and white fruits. In shape they were, however, a blend between the two sizes and shapes of the parents and lost the objectionable green of the male parent.

By breeding the white strain within itself, it was at once free from the purple of the "New York Improved" and, through isolation and selection, there has been developed a block of plants from twelve of which the present season samples are shown in Plate XII. These plants are productive, as a photograph of a single plant with twelve fruits, taken early in October, will bear

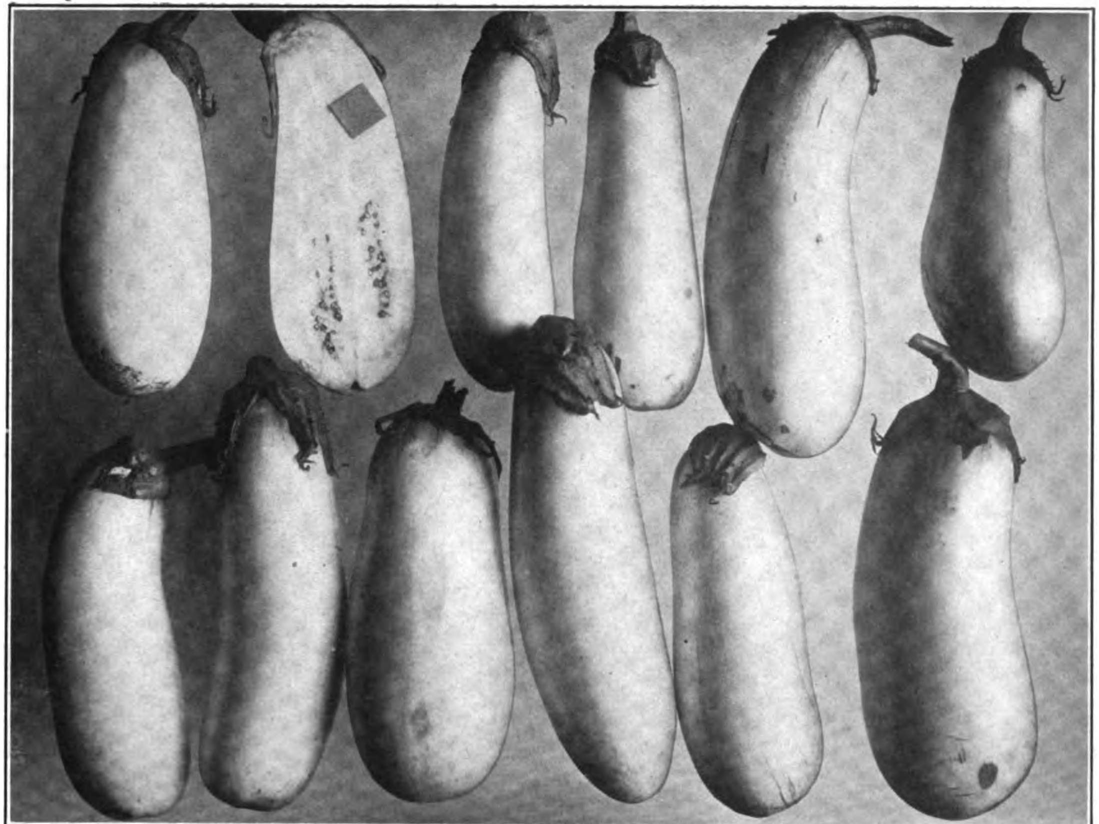


PLATE XII. *The "Ivory."* This new white variety resulted from the breeding of "Long White" upon "New York Improved." (11/18.)

testimony. The shape is all that can be desired, for they are convenient to handle in the market, are desired by the housewife for the convenient size for slicing, both for cooking and serving upon the table. The seeds are in the lower half of the fruit, as shown by the sample that is cut lengthwise and bearing a light gray paper an inch square to indicate the size of the fruit and the whiteness of the interior. If there is an objection to this fruit, it is in the absence of color to the exterior, which is so clear a white as not to be adequately described in this respect by the name "Ivory" that has been given to it. All who have had an opportunity to test the quality of this vegetable fruit are highly pleased with it and, aside from its desirable size and shape and pure whiteness, remarks most encouraging of the flesh, which shows its fine light color even after it reaches the table, have been freely offered.

The "Jersey Pink."

A few words will suffice for this variety for, in giving the origin of the "Ivory," that of the "Jersey Pink" is necessarily included, for both are alike in parentage and differ practically only in the color of the fruit, and that of the plant stems and leaves. At the time when the fruits are ready for market, the color is a rich pink but as they mature this is diminished somewhat.

In this variety there will be a small percentage of plants with white fruits but the practical grower may discard these as soon as observed. Theoretically, certain plants have none of the white blood and these, if isolated, would breed true, that is, produce no white offspring but as in similar cases the separation is not an easy matter all at once save by isolation or hand pollination.

The "Jersey Pink," to a very limited extent, was distributed to growers under the name of "Station Eggplant No. 2." This season adds emphasis to the footnote made in the report for last season that eggplant seedlings are not easy to grow.

Reports from Testers for the "Jersey Pink."

"Eggplants fair growth, quite productive." "Plants are larger and less subject to blight than those of 'Black Beauty' in the next row, and are also more productive and earlier. The fruits are long, mostly purple, a few white ones, all very good quality." "The plants are growing very nicely and the fruit is just developing, one is about five inches long. I think there will be a great many." "The plants are about two and a half feet high, very vigorous and productive, and full of blossoms, the fruit is mostly pink, some are white, long and of a nice size. The quality is of the best and when known well will be much sought for." "Strong, vigorous growth, and look very fine." "Best plant has seven fruits set; shape, uniform; quality, first class, plants have grown nicely since it has been warm enough. Have cut seven large enough to eat. Think it very promising for home use or for discriminating buyers of fancy fruits." "Good-sized plants, rapid growers, good bearers." "Good grower and productive." "The eggplants were very large; the fruit was long and thin." "Quality excellent; it is a large job for the good wife to fry enough to satisfy my appetite. Never had so many eggs before; twelve on one plant, all oblong." "The eggplant was of two colors; purple and white, but no difference in the taste, both were very toothsome and I consider it grew very well for me."

Hybrid Eggplants.

Plate XIII. shows a set of fruits gathered singly, or a cluster from each plant, thus representing fourteen individuals and nearly as many types of fruits. A sample fruit of the male parent of the union, namely, the common "American" eggplant is shown at the left hand upper corner (1) and the "Chinese" species, upon which it was worked in 1904, is shown in the opposite corner (16) of the plate. In 1905, the single blend plant was grown and the following is taken from the report for that year: "In a few words, this hybrid shows remarkable vigor, growing to perhaps three times the size of its parents, with a great tendency to produce blooms, which quickly fall away. It behaved like a perennial and did not find time in an unusually long season to mature more than two dozen fruits."

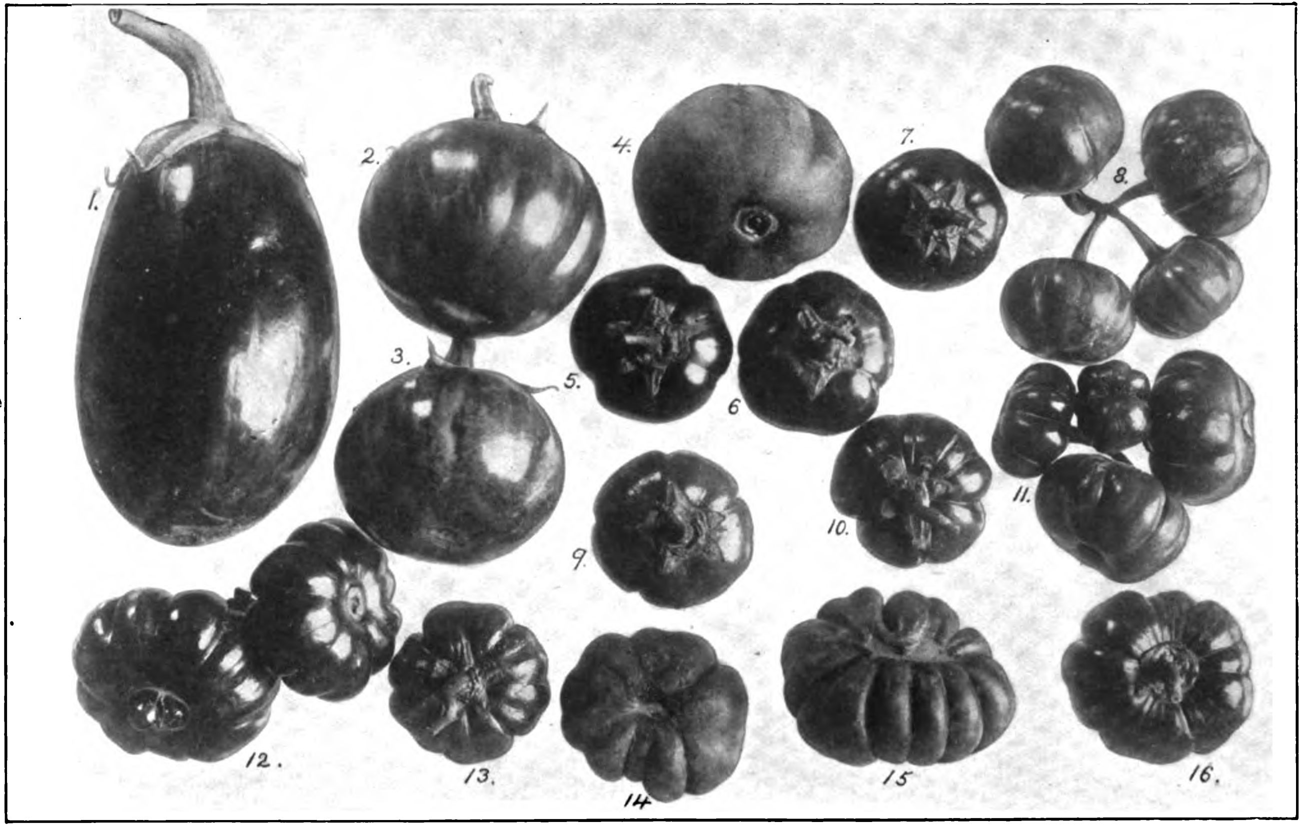


Plate XIII. *Hybrid Eggplants.* Fruits from plants of second generation from the blend of "Fordhook" upon "Scarlet Chinese" eggplants, with parent types at 1 and 16.

In 1906 thirty-six plants, representing the first generation from the blend, were grown in the Home Grounds, a record of which (in tabular form) was given and the following statement made: "It is, however, apparent that regarding the character of the fruit, the 'Chinese' exerts a preponderating influence over the 'American,' but it is to be remembered that the large size of the fruits of the latter is a cultural development, and, so far as affecting the hybrid, it may be that the small-fruited wild type might have been as effective."

In the crop for the present season, there is considerable range in the plants and their fruits, three of which resemble the "American" quite fully in foliage and the fruits of these are an advance toward the same desired end. Samples from three plants are shown at 2, 3 and 4, and it is seen that they are nearly smooth and of fair size. As a rule, the hybrid fruits are orange colored but the three in question are dark purple and closely resemble the ordinary fruits upon the surface. In the crosses between the hybrids and the "American" parent, it is hoped that a further progress may be made toward a fruit that will be of good keeping and table quality.

In the plate, the fruits are arranged somewhat in the order of their resemblance to the parent species, those of "Chinese" type bearing the higher numbers, but it is seen that they intergrade so thoroughly that such an arrangement is difficult. A statement of the qualities of the whole plant in each case is more to the point and it is given in the following table.

From the list of thirty-six plants of the hybrid "Fordhook" upon "Scarlet Chinese" (14/25), seeds from four plants, namely, Nos. 3, 13, 29 and 33 were selected and sets grown with the results as given upon page 322.

	Size.	Color.	Leaves.	Spines.	Flowers.	No. of Fruits.
Mother plant 3.						
No. 1, ...	Medium, ...	Purple, ...	Small, ...	No, ...	None,*	23
" 2, ...	Medium, ...	Purple, ...	Large, ...	No, ...	....	4
" 3, ...	Medium, ...	Purple, ...	....	....	Purplish, ...	4
" 4, ...	Dwarf, ...	Purple, ...	....	No, ...	Purplish, ...	4
" 5, ...	Medium, ...	Purple, ...	"Oak,"	No, ...	Purplish, ...	27
" 6, ...	Tall, ...	Purple, ...	....	No, ...	Purplish, ...	0
" 7, ...	Medium, ...	Purple, ...	Wrinkled, ..	No, ...	None, ...	0
" 8, ...	Medium, ...	Purple, ...	....	No, ...	White, ...	9
" 9, ...	Dwarf, ...	Purple, ...	....	No, ...	None, ...	10
" 10, ...	Medium, ...	Green, ...	"Oak,"	No, ...	White, ...	0
Mother plant 13.						
No. 1, ...	Tall, ...	Purple, ...	Wrinkled, ..	No, ...	White, ...	5
" 2, ...	Medium, ...	Green, ...	Medium, ...	No, ...	None, ...	0
" 3, ...	Tall, ...	Purple, ...	....	No, ...	None, ...	21
" 4, ...	Tall, ...	Purple, ...	Wrinkled, ..	....	None, ...	9
" 5, ...	Dwarf, ...	Purple, ...	Large, ...	No, ...	None, ...	0
" 6, ...	Tall, ...	Purple, ...	Wrinkled, ..	No, ...	None, ...	11
" 7, ...	Tall, ...	Purple, ...	Med. wrink.,	No, ...	White, ...	35
" 8, ...	Tall, ...	Green, ...	Wrinkled, ..	No, ...	White, ...	0
" 9, ...	Dwarf, ...	Green, ...	Wrinkled, ..	....	None, ...	16
" 10, ...	Tall, ...	Purple, ...	Wrinkled, ..	No, ...	Purple, ...	25
" 11, ...	Medium, ...	Green, ...	....	No, ...	White, ...	11
Mother plant 29.						
No. 1, ...	Dwarf, ...	Purple, ...	Large, ...	No, ...	Purplish, ...	19
" 2, ...	Medium, ...	Purple, ...	"Oak,"	No, ...	White, ...	25
" 3, ...	Tall, ...	Purple, ...	Medium, ...	No, ...	Purplish, ...	0
" 4, ...	Dwarf, ...	Purple, ...	Medium, ...	No, ...	Purple, ...	0
" 5, ...	Dwarf, ...	Green, ...	"Oak,"	No, ...	White, ...	23
" 6, ...	Tall, ...	Purple, ...	"Oak,"	No, ...	White, ...	12
" 7, ...	Medium, ...	Green, ...	Medium, ...	No, ...	Purplish, ...	0
" 8, ...	Dwarf, ...	Purple, ...	Medium, ...	No, ...	None, ...	0
" 9, ...	Medium, ...	Purple, ...	Medium, ...	No, ...	White, ...	11
" 10, ...	Dwarf, ...	Purple, ...	Medium, ...	No, ...	None, ...	0
" 11, ...	Tall, ...	Green, ...	Wrinkled, ..	No, ...	White, ...	10
" 12, ...	Medium tall,..	Purple, ...	Large, ...	No, ...	Purple, ...	21
" 13, ...	Medium, ...	Purple, ...	Medium, ...	Yes, ...	....	139
" 14, ...	Medium, ...	Purple, ...	....	....	Purplish, ...	10
" 15, ...	Medium, ...	Purple, ...	Medium, ...	No, ...	None, ...	0
" 16, ...	Tall, ...	Purple, ...	Medium, ...	Few, ...	Purple, ...	17
Mother plant 33.						
No. 1, ...	Medium, ...	Purple, ...	Medium, ...	Yes, ...	None, ...	75
" 2, ...	Dwarf, ...	Purple, ...	Small, ...	No, ...	None, ...	6
" 3, ...	Medium, ...	Purple, ...	Smooth, ...	Few, ...	Purple, ...	30
" 4, ...	Dwarf, ...	Green, ...	Medium, ...	Few, ...	None, ...	10
" 5, ...	Medium, ...	Green, ...	Wrinkled, ..	No, ...	White, ...	5
" 6, ...	Medium, ...	Green, ...	....	Yes, ...	White, ...	8
" 7, ...	Tall, ...	Green, ...	Medium, ...	Few, ...	None, ...	0
" 8, ...	Dwarf, ...	Green, ...	Small, ...	Yes, ...	None, ...	55

*No flowers were present at time observations were made, October 10th.

Plant 12 of the above series (from mother plant No. 29) was full of interest because of the acceptable spinelessness (which was absolute and not relative) of the plant in all its parts. The dark purple color prevailed in stem and foliage, making in this respect a plant closely akin to the "Black Snake" and the "Black Pekin" and their class. The flowers were produced in great abundance and were of good size and a rich light purple; they set well and the plant produced a dozen fruits that averaged ten ounces while as many more smaller ones were on the way to maturity when the October frosts brought an end to the life of the hybrid plant.

The fruits are a flat oval with very indistinct ribs and, when mature, of a color not easily described; for the upper end next to the calyx is a shade of purple with a suggestion of bronze, while the lower end is a true purple and the equatorial zone is a mixture of the shades of the two ends dove-tailed together and more or less mottled. In sectional view, the interior of the fruit resembles somewhat a large tomato with several seed cavities (locules) that, in themselves, are very irregular and partially divided and giving the impression of a large number of locules. The seeds are very few, thus furnishing a large percentage of pulp. When tasted raw, the flesh is bitter and indicates that much further breeding will be required before the ideal hybrid is secured, namely, one that is spineless, productive and the fruits of marketable size with a flesh that is desired for its palateableness. The firmness of flesh and its long-keeping quality are points already secured, to which may be added the other necessary characteristics of a plant to make it acceptable by the market gardener, as well as the amateur who enjoys novelties that are of worth.

A number of crosses upon this plant are in sight that will increase the percentage of the "American" parentage and probably bring out a diversity of form and color from which a choice may be made. The vicissitudes of plant breeding might make an interesting chapter were the full feeling of the breeder written into it. In the present case, the finest, largest and first fruit resulted from hand-working the flower with pollen from the "Ivory," but, just before the much cherished fruit was to be taken for seeding,

was removed by someone whose precise interest in it may never be known; it probably became an extemporized foot-ball (of small size) to gratify the lust for plunder in an apparently growing class of the uncontrolled.

A Fruitful Dwarf Hybrid Eggplant.

The block of hybrid eggplants was as noticeable for the great range in fruitfulness as in any other character. A glance at the table will show that there is, in a general way, a correlation between the size of the plants and their fruitfulness. All the very tall, broad plants that towered above their fellows were, as a rule, nearly or quite barren, while, upon the other extreme, the low plants (underlings) and particularly those of medium size were fruitful. An illustration of the latter is given in Plate XIV., where the lower portion of the plant is seen to bear over fifty fruits. This plant grew by chance in the same hill with one that was fully four times its height and breadth but produced no ripe furits. These "giants" are, as a rule, free bloomers, but for reasons not yet fully understood the fruits fail to form. This is not unlike the condition obtaining with the blend plants of the hybrid in question, which the summer through are covered with hundreds of flowers, but fruits at the close of season are almost entirely absent.

"American-Chinese" Eggplants; Derivative Hybrids.

Last year, twenty-four plants of a derivative hybrid of the "American-Chinese" eggplant were grown, that is, a combination of the above hybrid crossed upon by the "Chinese" and expressed by the compound fraction 25//14/25. Seeds from five of these plants were used for the continuation of the hybrid upon the breeding grounds the present season, namely, Nos. 1, 5, 7, 10 and 14, and they have given a very diverse lot of plants as described in tabular form below:

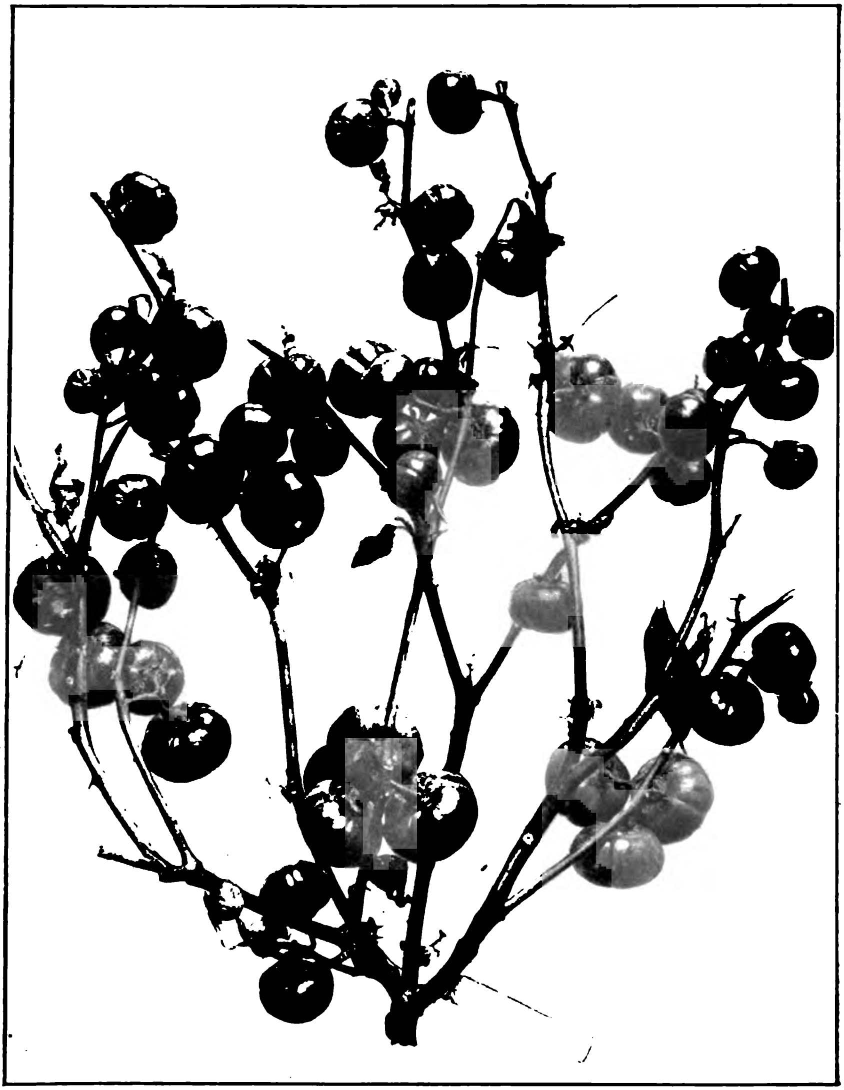


PLATE XIV. *A Fruitful Dwarf Hybrid Eggplant.* The stem was cut off close to the ground and the tips of the branches and many young fruits removed to accommodate the plant to the camera.

Mother plant 1 was medium-sized, with dark, smooth and purple foliage with no spines and bore 24 fruits.

	Size.	Color.	Leaves.	Spines.	Flowers.	No. of Fruits.
No. 1,........	Dwarf, ...	Purple, ...	Sm. smooth,.	No, ...	None,*	0
" 2,........	Dwarf, ...	Purple, ...	Med. smooth,	Yes, ...	White, ...	67
" 3,........	Tall, ...	Purple, ...	Med. smooth,	No, ...	White, ...	85
" 4,........	Dwarf, ...	Purple, ...	Sm. smooth,.	No, ...	Purple, ...	18
" 5,........	Tall, ...	Purple, ...	Med. smooth,	No, ...	Purple, ...	55
" 6,........	Tall, ...	Purple, ...	Wrinkled, ..	No, ...	Purple, ...	0
" 7,........	Tall, ...	Purple, ...	Wrinkled, ..	No, ...	White, ...	0
" 8,........	Medium, ...	Green, ...	Large, ...	No, ...	None, ...	3
" 9,........	Tall, ...	Purple, ...	Lar. wrink.,.	Yes, ...	White, ...	3
" 10,........	Tall, ...	Green, ...	Med. wrink.,	No, ...	White, ...	0
" 11,........	Medium, ...	Purple, ...	Med. smooth,	No, ...	White, ...	0
" 12,........	Tall, ...	Purple, ...	Large, ...	No, ...	Purple, ...	17
" 13,........	Dwarf, ...	Purple, ...	Med. smooth,	Yes, ...	White, ...	91

Mother plant 5 was medium-sized with stems green, foliage light green, spineless and bore 15 fruits.

	Size.	Color.	Leaves.	Spines.	Flowers.	No. of Fruits.
No. 1,........	Tall, ...	Green, ...	Wrinkled, ..	Yes, ...	White, ...	87
" 2,........	Tall, ...	Green, ...	Wrinkled, ..	Yes, ...	None, ...	0
" 3,........	Tall, ...	Green, ...	Smooth, ...	Yes, ...	White, ...	3
" 4,........	Dwarf, ...	Green, ...	Smooth, ...	Yes, ...	None, ...	0
" 5,........	Dwarf, ...	Green, ...	Wrinkled, ..	Yes, ...	None, ...	0
" 6,........	Dwarf, ...	Purple, ...	Wrinkled, ..	No, ...	Purple, ...	2
" 7,........	Tall, ...	Green, ...	Smooth, ...	Yes, ...	White, ...	35
" 8,........	Dwarf, ...	Green, ...	Smooth, ...	Yes, ...	None, ...	0

Mother plant 7 was low with purple stems and foliage, spiny and had 24 fruits.

	Size.	Color.	Leaves.	Spines.	Flowers.	No. of Fruits.
No. 1,........	Tall, ...	Purple, ...	Smooth, ...	Yes, ...	Purple, ...	177
" 2,........	Tall, ...	Purple, ...	Smooth, ...	Yes, ...	Purple, ...	67
" 3,........	Dwarf, ...	Purple, ...	Smooth, ...	Yes, ...	Purple, ...	4
" 4,........	Tall, ...	Purple, ...	Smooth, ...	Yes, ...	Purple, ...	58
" 5,........	Tall, ...	Purple, ...	Smooth, ...	Yes, ...	White, ...	79
" 6,........	Tall, ...	Purple, ...	Wrinkled, ..	No, ...	Purple, ...	46
" 7,........	Dwarf, ...	Green, ...	Smooth, ...	No, ...	None, ...	13
" 8,........	Medium, ...	Purple, ...	"Oak,"	No, ...	White, ...	4
" 9,........	Tall, ...	Green, ...	Wrinkled, ..	Few, ...	Purplish, ...	25
" 10,........	Tall, ...	Purple, ...	Smooth, ...	No, ...	White, ...	11

*No flowers were present at time observations were made, October 10th.

Mother plant 10 was a giant with purple stems and large leaves and few fruits.

	Size.	Color.	Leaves.	Spines.	Flowers.	No. of Fruits.
No. 1,	Medium,	Green,	Wrinkled,	Yes,	White,	24
" 2,	Tall,	Green,	Wrinkled,	Yes,	White,	1*
" 3,	Tall,	Green,	Wrinkled,	Yes,	White,	23
" 4,	Tall,	Green,	Wrinkled,	No,	White,	0
" 5,	Medium,	Green,	Wrinkled,	Yes,	None,	1*
" 6,	Tall,	Green,	Wrinkled,	Yes,	None,	0
" 7,	Medium,	Green,	Wrinkled,	Yes,	None,	31
" 8,	Medium,	Green,	Wrinkled,	Yes,	None,	11*

* Small.

Mother plant 14 was medium-sized with green stem and leaves, spiny and bore 27 fruits.

	Size.	Color.	Leaves.	Spines.	Flowers.	No. of Fruits.
No. 1,	Dwarf,	Green,	Wrinkled,	No,	None,	0
" 2,	Dwarf,	Green,	Smooth,	Yes,	None,	0
" 3,	Medium,	Green,	Wrinkled,	Yes,	None,	0
" 4,	Medium,	Green,	Wrinkled,	Yes,	None,	0
" 5,	Tall,	Purple,	Smooth,	Yes,	Purplish,	56
" 6,	Tall,	Green,	Wrinkled,	Yes,	None,	7
" 7,	Tall,	Purple,	Smooth,	Yes,	Purplish,	21
" 8,	Dwarf,	Green,	Smooth,	Yes,	None,	0

In fruit characteristics, there was considerable range; beyond the variations noted in previous years, some plants were with fruits of a decidedly yellow color, which is quite unusual and may throw some light upon the way such novelties come into existence. There was one plant that produced fruits that were russet-coated similar to this constant character in some varieties of apples. Perhaps the most striking of all the new shapes is the true egg form that is constant with a quite fruitful dwarf plant.

The Orange Oval Hybrid Eggplant.

In addition to being of a low, wide-spreading form as stated above, this plant bore an abundance of smooth, egg-shaped,

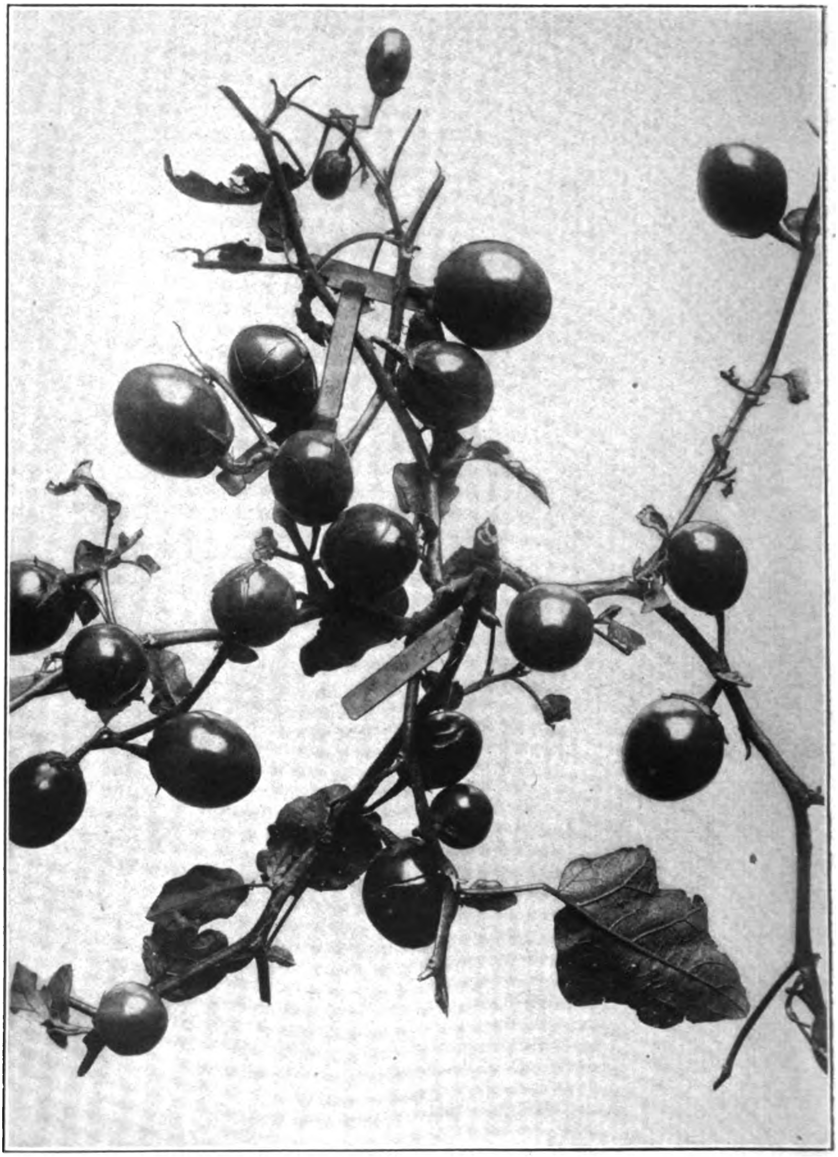


PLATE XV. *Orange Oval Hybrid Eggplants.* A portion of hybrid plant ("American Chinese") showing a new "egg"-shaped type of fruit.

orange-colored fruits, of quite a different type than had heretofore been obtained. The central portion of the plant with roots and short main stem removed, is shown bottom side up (for convenience in photographing) in Plate XV., the longer branches for half their length having been cut away, together with a large number of the smaller fruits. The calyx, stem and leaves are absolutely spineless, which is one of the important results of the breeding together of the two species, both of which abound generally in the undesirable prickles.

With this plant, the "Ivory" and the "Round White" have been bred with the hope of gaining size in the fruit and retaining somewhat of the firmness of the flesh so that long shipment may be made with safety.

"Pepper-leaved" Hybrid Eggplant.

Another plant of the 25//14/25 set, grown the present season, has shown remarkable deviation from the average by being quite small and low, not of the strictly dwarf type as that term is understood when used with peas, beans, and tomatoes. The plant in question is very slender in stem and the leaves are thin, smooth, dark green and nearly entire, thus giving the foliage much the appearance of the garden red pepper (*Capsicum annuum*), to which it is not distantly related botanically. The fruits are medium-sized for this generation of the hybrid, flatish, slightly corrugated and of a pale yellow color, the last characteristic being quite in contrast with the prevailing deep orange of the other associated plants. There being an entire absence of prickles makes this plant still more desirable as the starting point for future breeding.

"Dwarf Purple" and "Chinese" Eggplant Hybrids.

The "Dwarf Purple" and "Chinese" eggplant reciprocal hybrids have been grown the present season in both the blend and the first generation thereafter. The blend plants of the "Dwarf Purples" upon "Chinese" (6/25) made a row of plants very uniform in size, midway between that of the two parents, and bloomed abundantly. There was some variation among the plants

in the number of spines, which were as a rule long and stiff. The fruits were very scarce, there being 55 for twelve plants, including one barren plant.

In the reciprocal (25/6), the record shows that the row of plants was uniform with the above and, at a short distance, the two rows could not be distinguished as to size of plants, bushy habit, fine purple foliage and profusion of blossoms. There were some barren plants, the total crop of fruits being 35 from twelve plants.

In the first generation from the blend, the 6/25–I. showed great variation in many respects; in size of plant, some were tall, others truly dwarf, some had fine foliage and others bore large leaves, and in the matter of spines there were all gradations from perfectly smooth plants to those that had very many long stiff spines. Notes upon some points are lacking in the table below:

	Size.	Color.	Leaves.	Spines.	Flowers.	No. of Fruits.
No. 1,	Medium,	Purple,	Smooth,	Yes,	Purplish,	7
" 2,	Tall,	Purple,		Yes,	Purple,	35
" 3,	Tall,	Purple,		Yes,	Purple,	19
" 4,	Tall,	Purple,		Yes,		41
" 5,	Tall,	Purple,		Yes,	Purple,	71
" 6,	Dwarf,	Green,	Small,			37
" 7,	Dwarf,	Purple,		Yes,	Purple,	51
" 8,	Dwarf,	Purple,	Small,		Purple,	29
" 9,	Medium,	Green,		Yes,	White,	0
" 10,	Tall,	Purple,	Large,	Yes,	Purple,	6
" 11,	Dwarf,	Purple,		Yes,	Purple,	11
" 12,	Medium,	Green,	"Oak,"	Yes,	White,	105

The reciprocal (25/6) of the above generation showed an equally variable set of plants in all the respects above enumerated. One plant in this row (No. 4) was exceptional in having the fruits larger than any elsewhere and of a purple color, showing that it adhered more closely to the "American" type than any of its relations in the two rows. Plate XVI. shows some of the fruits gathered from the four rows in question, those at 1 being of the blend 6/25 and samples of its next generation are given to the right and representing six different plants, but no great range in

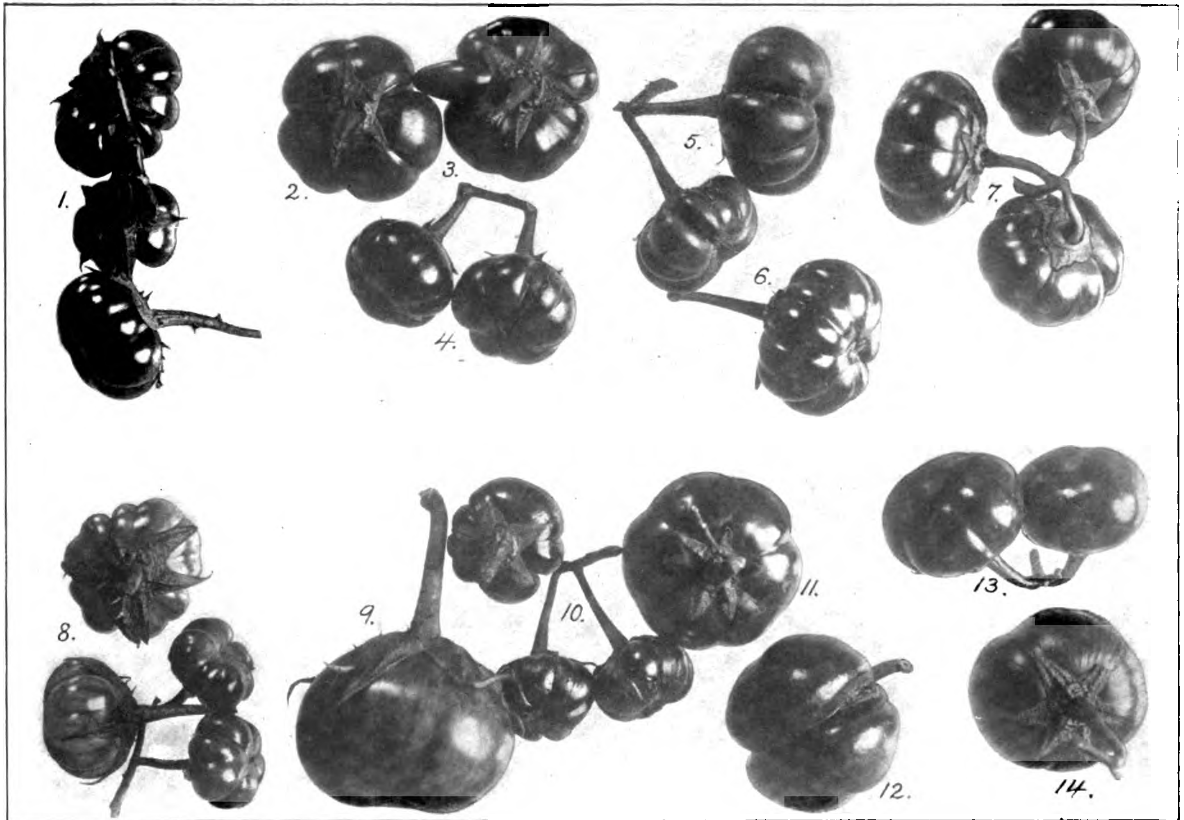


PLATE XVI. *"Dwarf Purple-Chinese" Hybrid Eggplants.* Samples of blend fruits are shown at 1, and of the reciprocals at 8; fruits of the next generation are given from 2 to 7 and their reciprocal below, 9 to 14, with an unusual type at 9.

size and shape. In the lower part of the plate at 8 are three sample fruits from the blend of 25/6, which are practically the same as those of the reciprocal shown above them. At 9 is the exceptional fruit previously noted that may be the starting point for a new variety of eggplant of commercial value. Further to the right are sample fruits from five plants and are quite like those of the reciprocal of the same hybrid generation shown above them.

In the table below is a statement of the facts for this set ot twelve plants closely comparable with that for the reciprocal row:

	Size.	Color.	Leaves.	Spines.	Flowers.	No. of Fruits.
No. 1,	Dwarf,	Purple,	"Oak,"	No,	White,	0
" 2,	Tall,	Purple,	Wrinkled,	Yes,	Purple,	4
" 3,	Tall,	Purple,	Wrinkled,	Yes,	Purple,	0
" 4,	Dwarf,	Purple,	Smooth,	Yes,	None,	21
" 5,	Tall,	Green,	Wrinkled,	Yes.	None,	6
" 6,	Dwarf,	Purple,	Smooth,	Yes,	Purple,	20
" 7,	Dwarf,	Purple,	Smooth,	No,	Purple,	7
" 8,	Dwarf,	Green,	Smooth,	Few,	None,	17
" 9,	Tall,	Purple,	Wrinkled,	Yes,	White,	5
" 10,	Tall,	Purple,	Smooth,	Yes,	Purple,	27
" 11,	Tall,	Purple,	Wrinkled,	Yes,	Purple,	111
" 12,	Dwarf,	Purple,	Smooth,	Yes,	None,	34

A Study of the Blossoms of Hybrid Eggplants.

The flowers of the hybrids between the "American" and "Chinese" eggplants, when brought together, make a set showing a wide range in size and color. In the American sorts, all members of the species *Solanum Melongena* have large blossoms, usually of a strong purple, but subject to considerable variation in this color as also in the size; the white sorts with no purple in the stems and leaves have the flowers, as a rule, of a pale color, as if the once purple blooms had become much faded. The Chinese species (*Solanum integrifolium*) has white flowers that are comparatively small and, therefore, any union between the two above-named species might be expected to give some differences in the blooms.

The chief hybrids are between the "Dwarf Purple" (6), "Fordhook Improved" (14) and "Pride of Sunnyside" (20). Flower clusters with an open blossom from a large number of plants of these hybrids are brought together in Plate XVII. In the upper left hand corner are a few blooms from a representative of the "American" species and, scattered among them, a few of the "Chinese" kind, the latter being easily distinguished by their smaller size, apparent whiteness of the corolla and, last but not least, the stout "spines" that are upon the stems. To the right of the parents are thirteen clusters from as many plants of the hybrid "Dwarf Purple" upon "Chinese," one generation after the blend. It is seen that from 2 to 13 there are two blossoms (4 and 10) that are larger and evidently darker colored than the others; Nos. 2 and 8 are quite small and nearly white, particularly the latter. From 14 to 19 are the reciprocals of the same hybrid in the same generation, in which the variations are practically the same as for the first group. The set from 20 to 35 is of "Fordhook" upon "Chinese" in the second generation from the blend, that is, one year further on than the set previously considered. Here, certain blossoms are conspicuous for their large size and purple color as, for example, Nos. 21, 30, 31 and 35, while others, as Nos. 20, 22, 23, 24, 26 and 29, are small and generally white. There are some that are intermediate, but the individual differences are not easily determined from a picture; if 26 is compared closely with 34 the great contrast in size and number of particular parts is apparent. The four numbers from 36 to 39 are of the blend of "Pride of Sunnyside" upon the "Chinese" and the uniformity of the blossoms is fairly well shown.

The whole lower third of the picture, including Nos. 40 to 62, are of the hybrid in which the "American" blood is cut down to a quarter by breeding the first hybrid to the "Chinese" again. The blossoms average smaller than elsewhere, and there are but a few that show the purple color and the larger size suggesting the "American;" Nos. 48 and 54 are, perhaps, the largest of these, and their corollas are thin and pale as well as small as compared with the purple parent given in 1.

There is no great satisfaction in showing the flowers as a means of illustrating the individual differences in plants of a hy-

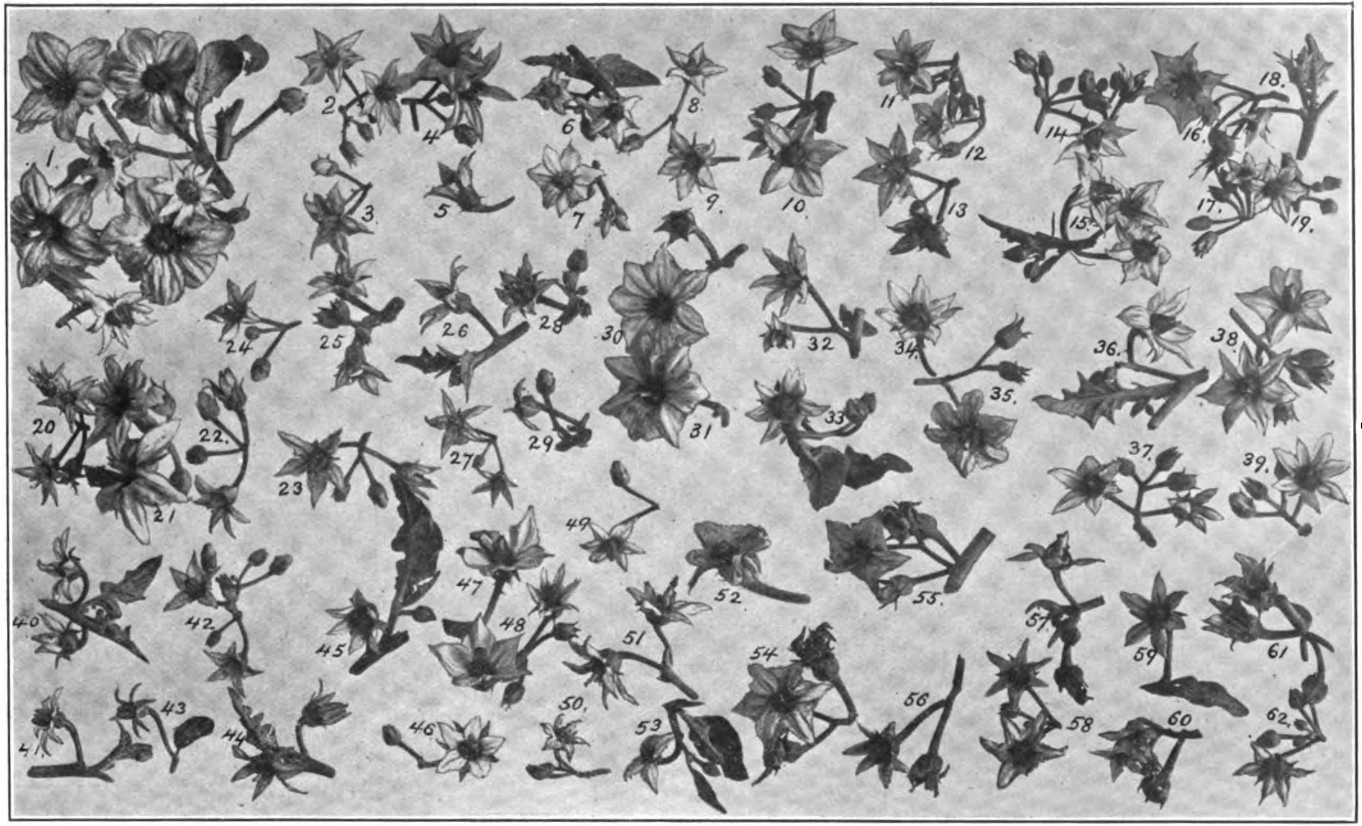


PLATE XVII. *Hybrid Eggplant Blossoms.* A set of sixty-two flower clusters from as many plants showing great variations, as compared with the two parents seen at 1.

brid like this, for the whole plant varies from habit of growth to the notches in the leaves, some are dwarf, others tall, some smooth, others spinose, some green, others purple, some fruitful, others entirely barren, all of which differences enforce the rule that hybrids may give rise to many types and some of them are not easily accounted for from a study of their immediate parents only.

The Spinoseness of Eggplants.

One of the objectionable features—perhaps the chief—in handling eggplants is the stiff prickles that are usually present upon the base of the calyx and the stem of the fruit. This troublesome spinoseness has stimulated seedsmen to place the term "spineless' or "smooth" in the trade names of their eggplants long before the facts in the case would fully warrant it. The person who has been familiar with the crop in question in a practical way can speak feelingly upon this point and may agree that any efforts to eliminate the prickers are along a desirable line.

The "spines" in question are evident before the flower-bud is open and this renders it easy to decide early in the life of the plant as to its freedom from prickles; in fact an earnest of the spinoseness may be gained from the stems and foliage of the young plant before it has begun to form any organs for reproduction. The prickers are in particular upon the lower side of the main veins of the leaf, and may be quickly detected by drawing the back of the hand along under the leaves while they are still small. In the worst cases of spinoseness the objectionable sharp outgrowth is upon the stems in nearly all their parts.

A good opportunity of displaying the relative amount of spinoseness is offered by the young fruits taken soon after the corolla falls. Such a set is shown in Plate XVIII., in the order of the numbers in the engraving, upon which the following very brief notes are made:

1. "Black Snake" (2). Practically spineless.
2. "Black Pekin" (3). Practically spineless.
3. "New York Spineless" (9). Far from smooth.
4. "Early Dwarf Purple" (5). Spineless.
5. "Florida High Bush" (8). Very spiny.

6. "Long Purple" (12). Nearly smooth.
7. "Long White" (11). Has some stout prickles.
8. "Mammoth White Pearl" (15). Shows spines upon the stem.
9. "Round White" (26). Smooth.
10. "Striped" (21). Large spines.
11. "Station No. 1." Smooth.
12. "Station No. 2." Smooth.
13. "Jersey Belle" (10). Some spines.
14. "Jersey Pink." Some spines.
15. "Ivory." Some spines.
16. "Scarlet Chinese" (25). Spiny.
17. "Black Snake/Dwarf Purple" (2/5). Smooth.
18. "Black Snake/Dwarf Purple" I (2/5 I). Nearly smooth.
19. "Black Snake/Early Dwarf Oval" I (2/6 I). Spiny.
20. "Black Snake/New York Improved" (2/18). Spiny.
21. "Fordhook/Scarlet Chinese//Long White/Dwarf Purple" (14/25//11/5). Spiny.
22. "Black Pekin/Black Snake" (3/2). Smooth.
23. "Black Pekin/Dwarf Purple" (3/5). Some spines.
24. "Dwarf Purple/Black Snake" (5/2). Smooth.
25. "Early Dwarf Oval/New York Improved" (6/19). Spiny.
26. "Early Dwarf Oval/Scarlet Chinese" (6/25). Spiny.
27. "Early Dwarf Oval/Scarlet Chinese" I (6/25 I). Nearly smooth.
28. "Scarlet Chinese/Early Dwarf Oval" I (25/6 I). Spiny.
29. "Scarlet Chinese/Early Dwarf Oval" (25/6). Very spiny.
30. "Jersey Belle/Black Snake" (10/2). Very spiny.
31. "Jersey Belle/Early Dwarf Oval" (10/6). Some spines.
32. "Jersey Belle/New Excelsior Tree" (10/17). Nearly smooth.
33. "Long White/Black Beauty" (11/4). Some spines.
34. "Fordhook Improved/Scarlet Chinese" II, Plant 29 (14/25 II, Plant 29). Some spines.
35. "Fordhook Improved/Scarlet Chinese" II, Plant 33 (14/25 II, Plant 33). Some spines.
36. "Pride of Sunnyside/Black Beauty" (20/4). Some spines.
37. "Pride of Sunnyside/Scarlet Chinese" I (20/25 I). Very spiny.
38. "Scarlet Chinese//Fordhook/Scarlet Chinese" Plant 1 (25//14/25, Plant 1). Spiny.
39. "Scarlet Chinese//Fordhook/Scarlet Chinese," Plant 5 (25//14/25, Plant 5). Spiny.
40. "Scarlet Chinese//Fordhook/Scarlet Chinese" Blend (25//14/25, Blend). Spiny.

Notes Upon the Calyx Character in Eggplants.

As noted in previous reports, the calyx of eggplant fruits is far from constant in the character of color and also of the surface of the fruit beneath the calyx.

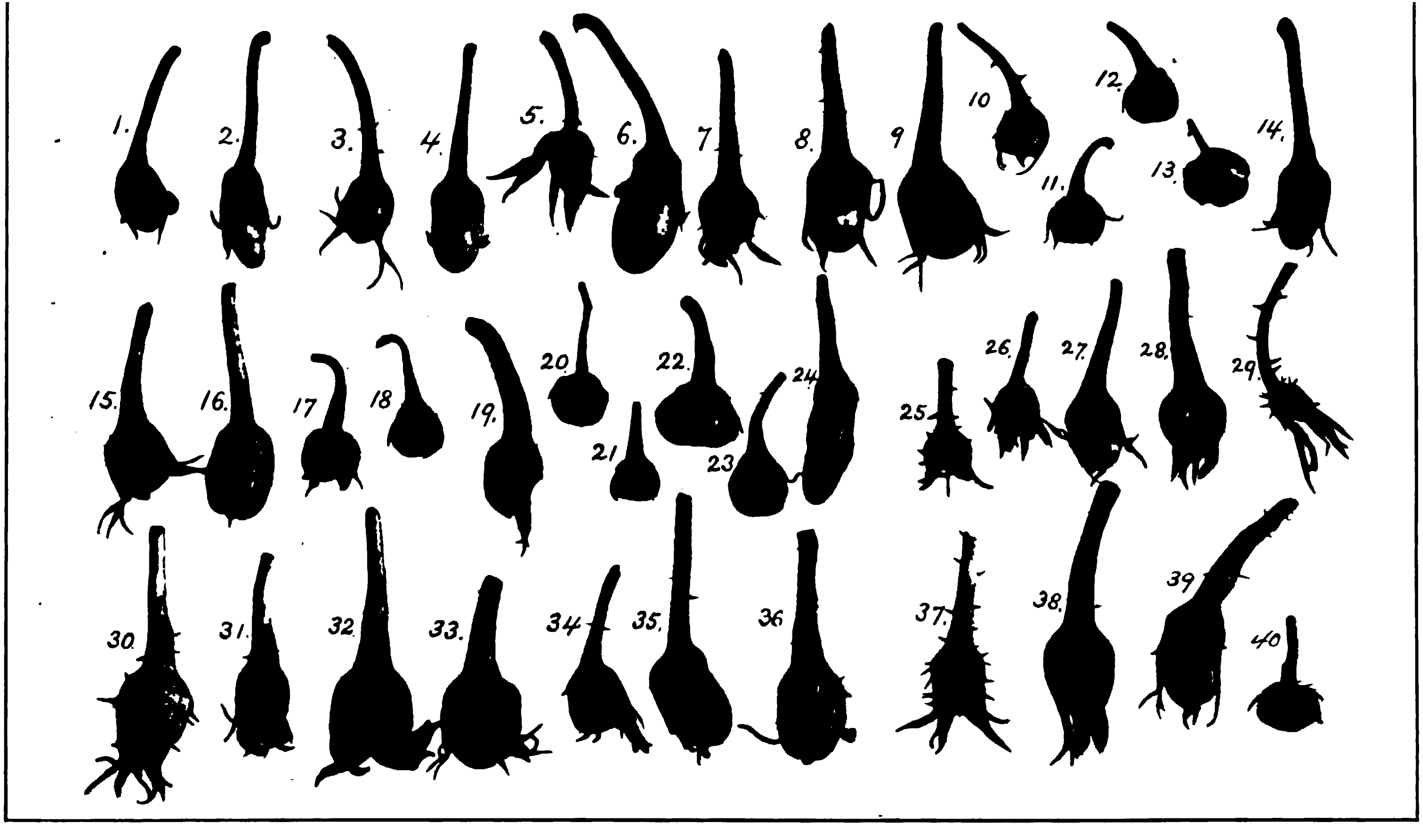


PLATE XVIII. *Calyx Character Among Eggplants.* Young fruits from forty plants were photographed, showing the calyx in particular, and its spinoseness.

The "Black Snake," "Black Pekin" and "Dwarf Purple" all have the purple color of the exposed portions of the fruit absent from the protected part beneath the calyx. In the "Black Snake" the exposed surface of the fruit is a fresh light green, while that of the "Dwarf Purple" is nearly white (or a very pale green), and the "Pekin" has a shade of blue somewhat between the two, but more like the "Black Snake" than the "Dwarf Purple."

The "Jersey Belle" has a large calyx with several unequal lobes that extend down from the green stem and enclose the fruit until it is two inches in length. It is also thick, somewhat ribbed, with a few "spines" near the base, and has the prevailing color green with some showing of purple upon both the outside and the inside, the latter appearing as broad, irregular veins as the lobes are lifted for inspection. Upon the other hand, the "Dwarf Purple" has a small thin calyx that extends from the purple stem only a short way upon the fruit, often in only two lobes, and is of a deep purple upon the outside, pale purple beneath and not showing distinct veins. Prickles or "spines" are rarely met with upon the calyx, and those upon the fruit stalk are small and inoffensive.

The cross between the two above-mentioned sorts is more like the "Dwarf Purple" in its calyx than the other parent, being purple throughout the whole exterior, including the fruit stalk. The color is not so deep as in the "Dwarf" parent, and there are strong indications of the "blood" of the "Jersey Belle" in the ribs and the prickles—the grooves in the stem in particular showing streaks of green; the under surface of the calyx is purplish green. In size the calyx is medium between the two parents and, therefore, extends over the fruit much further than in the "Dwarf Purple." The point of particular interest is the color of the surface of the fruit beneath the calyx, which is a pale purple or dark pink and shows belts of deeper color at the lower margin where, by growth, the fruit has extended beyond the calyx.

In the "Dwarf Purple," when the calyx is removed the area it covered is seen with distinctness; the purple meets the pale green sharply. In the young fruits this line is less pronounced,

because the growing fruit causes a series of fine bars or "waves" suggesting the shore line of the sea when near a calm.

The "Jersey Belle" shows, even in the young fruit, the purple color beneath the calyx, and when the latter is lifted there is no indication in color as to the portion that was unexposed. When the base of the fruit is reached the purple color ceases and the border is white and, meeting the purple in an irregular line, somewhat blends in a pale purple belt.

The cross shows an interesting blending of the two parents. When the calyx is lifted there are seen broad wave lines of purple near the base of the area covered, due (as before explained) to the extending of the fruit in growth beneath the calyx; and extending from the complex border is a light purple that fades into a very pale green as the base of the calyx is reached. In other words, the pure dark purple of the one parent and the pale green of the other is replaced by a fair average of the two, namely, the pale purple above mentioned.

In general terms, the above statement obtains with the cross of the "Jersey Belle" upon the "Black Snake" with this difference, that, as above mentioned, the "Black Snake" has much more green under the calyx than the "Dwarf Purple," and the cross shows a corresponding increase in the green. As the "Black Snake" is inclined to be streaked, so the cross shows this feature even under the calyx. It is noted in passing that, as the "Black Snake" is a "spineless" sort, the cross has some individual plants without prickles upon the calyx.

In the purple fruits of the "Long White-Black Snake" cross the calyx is large, long-pointed, with lobes that incline to be retuse and a mixed purple and green, as is also the fruit stalk. Under the calyx border are the usual bands of unequal purple, while the main portion of the area is green, corresponding closely to that of the "Black Snake." So far as color is concerned, the cross is the same as the color-bearing parent—the white seeming to have no influence upon the amount of purple present.

EXPERIMENTS WITH LIMA BEANS.

The experiments with Lima beans have been chiefly the continuation of the crosses that have been obtained in the "breeder rows" between the "Jackson Wonder" and several white-seeded sorts.

The "Jackson Wonder" Crosses.

Selections of five color seed-types were made from the 265 plants representing the several "Jackson Wonder" crosses grown in 1906. The number of parent plant in each of the crosses under the several types is shown at the left hand in the following table:

Parent Type.	"Jackson Wonder" Type.	D. Red.	L. Red.	Mott. Red.	White.
"Jackson Wonder" Type,	132	12	14	11	28
Dark Red "	14	48	29	1	19
Light Red "	2	19	62	6	30
Mottled Red "	12	1	13	19	15
White "	20	14	5	7	185
	180	94	123	44	277

As might be expected, the "Jackson Wonder" and "white" (that is, parental) types show the least variation, two-thirds of the "Jackson Wonder" and six-sevenths of the white progeny breeding true. From the dark red parentage, one-half of the resulting plants gave seeds with either dark or light red, while one-half reverted to the parents. Results from the light red give three times as many whites as "Jackson Wonder," but, placing the mottled reds with the "Jackson Wonder," the solid colors, 81 in number, are found to be a little over twice those conforming to the parent types. The mottled red gives practically the same numerical results as the "Jackson Wonder" type.

The plants of the "Jackson Wonder-Burpee" combination were a uniform set, of good bearing quality and with more spreading habit than the "Jackson Wonder" with the earliness of the latter parent. The "blend" of this cross, with a large, dark-red seed,

was continued this year with the hope of securing a good white-seeded plant and gave twelve plants with the following results in seed color: "Jackson Wonder" type, 2; dark red, 4; light red, 3; white, 3.

The plants of the "Jackson Wonder-Henderson" cross were an even lot as both plants are similar in general plant characters. The prolificness of the "Jackson Wonder" is apparent in the white-seeded strain with beans somewhat larger than those of the "Henderson."

In the "Jackson Wonder-Willow-leaf" combination, three types of foliage are distinguished, the true Sieva of the "Jackson Wonder," the "Willow Leaf" and an intermediate. The object sought here is a more productive "Willow-leaf" plant, the narrow foliage and, therefore, open plant being a possible advantage. Nineteen "Willow-leaf" plants with white seed, varying in productiveness from the "Henderson" to the "Jackson Wonder," were obtained.

The "Jackson Wonder-Wood's Prolific" was grown in two separate lots, the "Runner set" being given the use of poles to encourage the tendency so strongly manifest last season. Of the 121 plants grown from this set, 84 had the true pole and 37 the bush form. The true bush plants of this cross gave progeny which, though of spreading habit, showed little running tendency. Their bearing quality was good, the pods being flat and of medium size.

The "Jackson Wonder-Station Bush," represented by the largest number of plants (forty-two), gave a fine even lot of offspring, early to medium-early, with medium-sized pods, while the bearing quality was excellent. Many of the seeds resembled the "Dreer" in plumpness.

Plate XIX. shows in the upper row a set of five types of color markings of "Jackson Wonder-Willow-leaf" seeds as found in a set of twenty-four plants, all grown from the dark red seeds of a single plant in 1906. The grandparent was a blend seed, the first generation from it split up into various color types and, from the progeny of a dark red set, the present one is selected as a representative of the second generation from the blend. The

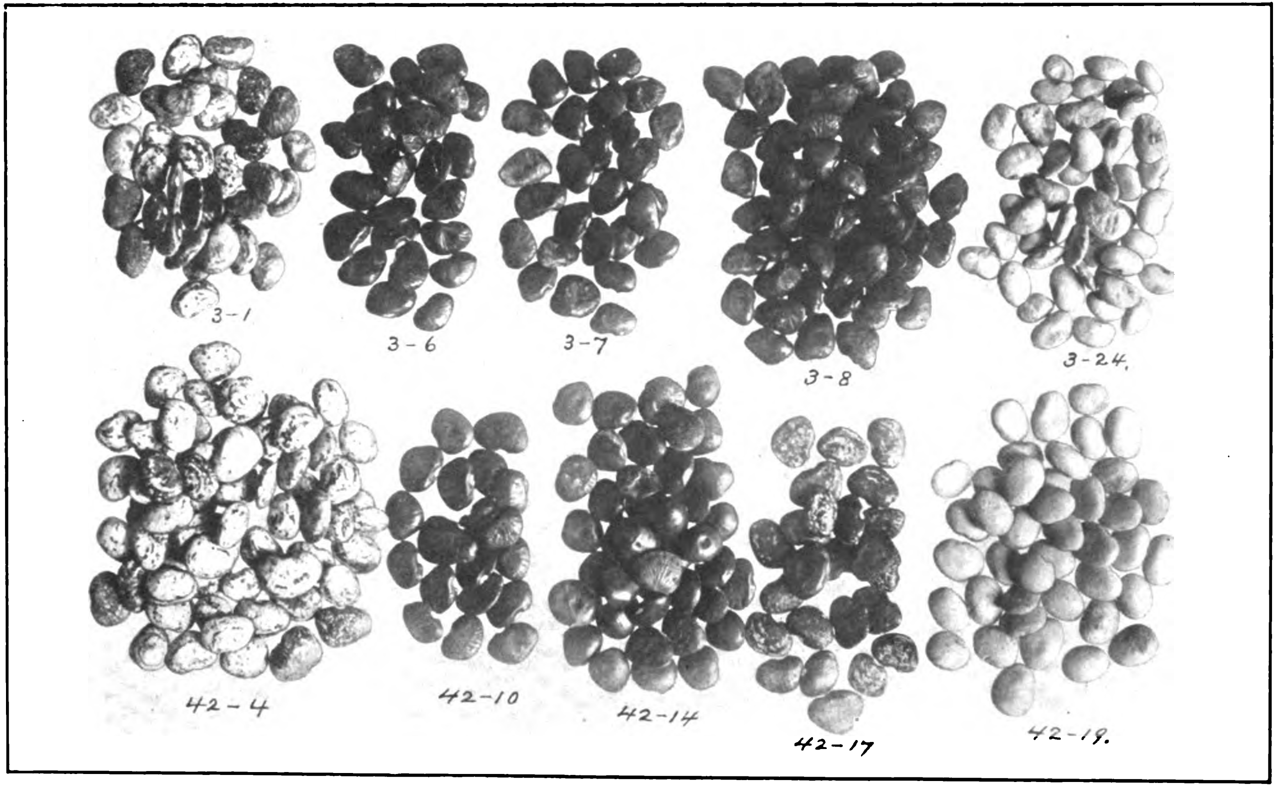


PLATE XIX. *"Jackson Wonder" Crosses.* The upper row is of crosses with the "Willow-leaf" in its five leading types of seed markings, a corresponding set with "Station" being given in the lower row.

formula is: 91/97 B–3–1,* B–3–6, B–3–7, B–3–8 and B–3–24, looking from left to right. The first, "Jackson Wonder," and the fifth, "Willow-leaf," are the parent types; the second is a dark red like its own immediate parent, the third is similar to the second in being solid color but a light red, while the fourth is mottled dark upon a brick red background.

The "Jackson Wonder" itself is a variable sort, the seeds sometimes being quite dark and, at other times, the basal color is dark and the darker blotches are therefore indistinct. The brick red of number four, while blotched like the "Jackson Wonder," is so different in the color of its background as to permit its being separated from the parent type. The shade of red here varied greatly so that the sample shown is one that stands for many small varieties.

In the lower row is shown the seeds of five plants in the second generation of a cross of "Jackson Wonder" upon "Station," and in this cross the immediate mother of them all produced uniformly light red seeds. The formula for this is: 91/217 B–42–4, B–42–10, B–42–14, B–42–17 and B–42–19; that is, the sixth in the Plate is from plant No. 4, which is from plant No. 42, which is from the blend. The color types are very close to those shown in the upper row. The darker reds, 3–6 and 42–10, are quite similar, as also the other solid color set, 3–7 and 42–14, but in 42–17 the background is lighter than in 3–8 and suggests, therefore, a still closer affinity with the "Jackson Wonder."

If a set for the Plate had been selected from all the crop

* To simplify record-making, the following scheme is used: The first generation is called the Blend, in which the characters of the two parents are often quite evenly united, and from the blend seeds the first generation after the blend is produced. The letter B stands for the Blend, and, following it with a dash between, is the number of the plant involved in the line of descent. The second generation, in the same manner, is indicated by the plant number concerned in the strain, and so on so long as the work continues, generation after generation. The following formula, B–3–21–14–7, shows that the work is expressed for four generations from the blend, and that the description, etc., that follows it concerns the 7th plant—in a list of any number, whose immediate ancestor is the 14th plant of the set making up the third generation, which in turn is descended from the 21st plant of the second, and the 3d in the first generation after the blend.

indiscriminately, a larger number of color types could have been shown, but those given are the chief ones quite constantly met with in all the crosses of the "Jackson Wonder" with the various kinds of white Lima beans.

"Jackson Wonder-Dreer" Cross.

The blend of this cross made its appearance last year, and is one generation behind the crosses given above; it was of strong spreading growth with the large, light-green leaves of the "Dreer" type, a prolific bearer of good-sized pods, thicker than those of the "Jackson Wonder" and containing dark-red seeds of medium size. The twenty offspring from this plant, grown the present season, were of low, spreading habit, about half showing the "Dreer" foliage.

The plants in general were prolific and medium early, two were of the "Jackson Wonder" type in seed color, fourteen dark red, one light red and one greenish white. The last-named was a seed much smaller than either parent, with the "Dreer" plumpness, promising the superior table quality and color of one parent combined with the prolificness of the other. One pronounced "Dwarf" was especially small, scarcely more than three inches high, of compact growth with leaves of the "Dreer" type and bore but one short, thick pod.

Selection Experiment with "Kelsey" and "Station" Lima Beans.

In 1906, a small plot was devoted to a crop of "Kelsey" Lima beans using selected seed. From this lot of plants, the best individuals were selected and from them, the best seeds were planted the present season. The seed of the best plants has been saved separately for a continuation of the selection experiment.

With the "Station," one lot of seed was selected for their "flatness" and another because of unusual "plumpness." Last year, the "plump" strain showed a great tendency to run, and this has so much increased the present season that this strain has been discarded as practically worthless.

Selection Experiment with "Jackson Wonder" Lima Beans.

The "Jackson Wonder" variety exhibits much variation in the amount of color in the seeds and a selection experiment has been running for four years to fix a light and a dark strain. Thus, each season a set of seeds showing the least amount of red or purple blotching was planted under isolation and, likewise, a comparable plot with seeds of the oppoite extreme, that is, those having the greatest amount of the color. Last year, the conclusion was that the "selection has removed much of the white in the series of dark seeds, while the opposite is not so evident, namely, the seeds after three years of selection for whiteness are nearly as much colored as the regular stock of the variety." From the results of the present season there appears to be no decrease in the amount of color in the light lot while, contrariwise, the crop grown from the selected dark seeds averages much darker than last year. This lot, however, contains a great variety of seeds ranging all the way from white (in one plant) to those of a solid dark purple. A comparison of seeds of different years, furthermore, shows that the color of "Jackson Wonder" beans changes materially with age, the gray white of the blotched typical seeds becoming light brown.

General Observations Upon Lima Beans.

That natural crossing among the Limas is easily accomplished through the aid of insects seems apparent from the results gained in the "Jackson Wonder" experiments, where one variety, being dark-seeded, readily marks itself upon a white-seeded sort and the blend is readily distinguished by its usually solid dark red seeds or by those that are slightly mottled.

That the running tendency lies dormant in the bush varieties seems apparent in the resulting crosses; thus, the "Jackson Wonder-Dreer" blend has shown a strong tendency in that direction, and it was this character which led to the selection of "Jackson Wonder-Wood's Prolific" "Runner set." Seed from cer-

tain plants of the "Station Bush," that inclined to twine, was selected in 1905 and has developed into a true pole variety.

The "Willow-leaf" foliage in the Limas is a variable one, and gradations from the very narrow form of the true "Willow-leaf" to the broad "Willow" approaching the Sieva foliage may be met with in any block of crosses of this variety.

EXPERIMENTS WITH BUSH BEANS.

Bush, or "snap," beans occupied a large part of the strips, where they were planted in blocks that separated the several plots of sweet corn. The following are the crosses that show most of promise and from which seeds, selected from the choicest plants, have been saved for further testing upon the Home Grounds and, in some instances, elsewhere by those who may desire to grow them.

"Everbearing Cylinder" (17/110).—The "Everbearing" is a variety with long, flat, green pods, bearing flat white seeds; and the "Cylinder" has a long, round, stringless wax pod, with black seeds. The white seeds of the cross were used for the present crop and no plant showed any color in its seed or blossom. From the mother came the compact bushy type of plant and the stringless wax pod and, from the male parent, the desirable white seed. The round pod of the "Cylinder" failed to appear upon any of the seventy plants.

"Longfellow-Marrowfat" (26/29). This gave an even lot of plants with long, straight, round pods of the male parent. The pods, although brittle and tender, are not stringless when ready for market.

"Longfellow-Davis" (26/112). Plants from the selected white seeds had the upright habit of "112," and bore plentifully of long, straight, flat wax pods, which, while resembling the "Davis," were less stringy.

"Davis-Keeney's Refuge" (112/133). Here again, selection for planting was made of the white seeds, and a desirable type of plant and pod was secured.

"Detroit-Black Wax" (113/117). From this cross has been selected the round-podded type, and it has proved to be of super-

ior quality, being an early, prolific bush, with medium-sized, round, brittle, stringless wax pods. The set of plants was remarkable for its uniformity in all respects.

"Golden Scimitar-Davis" (129/111). The white-seeded plants of this cross were used for continuation of the breeding, and a choice lot of medium late plants was grown, bearing an abundance of long, curved, round pods.

"Jones' Stringless-Golden Eye Wax" (131/130). This cross, continued from selected white seed, was represented by a large number of plants and proved to be an even lot of early, prolific plants with medium-sized, flatish wax pods. No strictly round pod has appeared, but the superior quality of the "Jones" parent is shown in the brittleness of the pod, which has little or no string at the marketable stage. It is the intention to offer this freely for testing by the truckers.

"Crystal-Brittle Wax" (145/101). Of the several types, in pod and seed, which have resulted from this combination, the round, white wax seems the most promising, being prolific and very brittle, although not entirely stringless. The white-seeded "Crystal Wax" pods (larger than the parent) which have appeared thus far have, with few exceptions, been tough and stringy, lacking the brittleness common to both parents. Selection of individual plants with the "Crystal" pod and least stringiness has been made with the hope of securing the desired results. Certain plants have given long, round, white-seeded green pods, from which selection has also been made.

"Crystal-Davis' Wax" (145/112). The selected white seed has bred true, giving low-spreading plants, medium late in season, with an abundance of medium-sized, round, straight or curved white wax pods, very brittle and practically stringless. This promises a variety of excellent quality for the later market.

More Recent Bean Crosses.

Of the eighty-two crosses grown on the Strips this season, twenty-nine resulted from last year's pollination, and, while promising some desirable new combinations, with one or two exceptions have not been carried far enough to warrant a detailed description.

"Black Valentine-Crystal Wax" (45/145). The reciprocal of this cross was pictured in the last annual, giving a desirable round-podded "Black Wax," but with the above combination results have been different. No wax pod has appeared, although the "Crystal Wax" types of pod and seed are in evidence, but in the case of 145/45 neither the type of pod nor of seed belonging to the male parent have occurred in any generation of the cross, in all, representing several hundred plants.

"Crystal Wax-Market Wax" (145/135). This cross is mainly interesting because of its seed variations. The blend plants were spreading, with strong running tendency, bearing plentifully of medium-sized, flat green pods with a dark mottled seed, appearing black when dry. In the breaking up of the blend, "Crystal Wax" pods and white seeds appeared, but the pod quality was inferior, due largely, no doubt, to the fact that both parents are stringy. From the combination of the white and yellowish brown seeds of the parents, the following types have resulted: Black, mottled, two shades of brown, and white.

Of the remaining twenty-seven crosses, the following promise most from the standpoint of good parentage:

"Brittle Wax-Pencil Pod Wax" (101/148).

"Davis-Lima Wax" (112/175).

"Crystal Wax-Canadian Wonder" (145/8). Here a new type is sought for in the shape of an upright, bushy plant, bearing large, broad "Crystal" (silvery grey) white-seeded pods.

"Pencil Pod-Burpee White Wax" (148/149). This cross may unite the fine, round, stringless pod of the former with the earlier season, and white seed of the latter.

Promising "Dry Shell" Crosses.

Certain combinations under the "Less Desirable" group last year, as "Lightning-Marrowfat" (25/28), were spoken of as promising a "dry shell" bean. By that is meant a variety which has no special pod merit, but produces a seed (usually white) which is desirable for cooking when dry. Commercial varieties of recognized merit for this purpose are the "Prolific Tree," "Burlingame Medium," "Yellow Eye," "White Marrowfat," "White Kidney," and "Red Kidney."

"Lightning-Marrowfat" (25/28). Neither parent produces a good snap bean, pods of both being flat, tough and stringy. The one merit of the "Lightning" is its extreme earliness, and this quality, combined with the more prolific white-seeded "Marrowfat," has produced a medium, prolific bush plant, free from the running tendency of the mother. The flat green pods are of medium size, containing seeds smaller than the "Marrowfat."

"Lightning-Prolific Tree" (25/34). The "Prolific Tree," as its name indicates, bears an abundance of rather small, flat pods upon a late plant. The white seeds are a "Pea" bean and of fine cooking quality. The resulting cross gives evidence of more earliness.

"Lightning-Davis' Wax" (25/111). This cross has resulted in large plants with flat green pods containing white seed of the "Davis" type, which resemble the commercial "White Kidney," though smaller. It promises a desirable new Kidney bean.

"White Marrowfat-Canadian Wonder" (29/8). The mother plant is distinguished by its large, thrifty, bushy plant with very long, flat, green pods. The seeds of the cross resemble those of the "Red Kidney," but are of a darker red and larger, with the rich quality of that variety. Either the "White Kidney" or the "White Marrowfat" type of seed, combined with the richness of the "Canadian Wonder," is desired in this cross.

"Green Winter-White Marrowfat" (51/28). Here it is desired to combine the earliness of the "Green Winter" with the large, round seed of the "White Marrowfat." Another white "medium" variety seems possible through judicious selection.

"Burpee's Brittle-Wonder of France" (101/52). Both parents have medium-early, bush plants, while "Wonder of France" has a medium-sized white seed and is a good bearer. The expected round pod has failed to appear in this cross, but a white-seeded green pod has resulted with medium-sized beans, promising another good variety.

Novelties or Commercial Kinds Not Before Grown in the Gardens.

The following varieties have been added to our list for 1907 and assigned record numbers as seen below:

No. 200. *"Black Eye Wax"* (Leonard). An early, medium-sized bush, pods medium length, flat, curved. Seed resembles "Golden Wax."

No. 201. *"Celestial Wax"* (Tait). This is an early "Black Wax."

No. 202. *"Double Barreled Wax"* (Landreth). A medium long, round, curved, early wax pod, flowers pink, seeds resemble the "Yellow Six Weeks."

No. 203. *"Early Cholet"* (Hend.). A small bush plant, early in season, with long curved pods, seeds golden brown with darker eye.

No. 204. *"Golden Queen"* (Greg., Noll). Strong-growing plants with long, flat, curved wax pods; medium early, seeds a mottled red.

No. 205. *"Landreth's Wax"* (Landreth). Plants of good size, early, bearing flat, curved pods, seed mottled dark red.

No. 206. *"Long Pod Forcer"* (Thorburn). An early, long, flat, curved green pod with seeds of the "Six Weeks" type.

No. 207. *"Michigan White Wax"* (Ferry). An early, medium length, rounding, curved, wax pod, with white flowers and seed.

No. 208. *"New Pearl"* (Bolgiano). Strong-growing plants, pods similar to those of "Golden Queen," mottled red seeds.

No. 209. *"Powell's Yellow Giant"* (Vick). This proves to be a Pole bean with large, flat wax pods and white seeds.

No. 210. *"Sunshine Wax"* (Bolgiano). Bush plants bearing medium-early, small, flat, curved wax pods, flowers and seeds white.

No. 211. *"Wingold Wax"* (Maule). Plant medium in size, bearing early, short, rounding, curved wax pods, seed has dark "eye."

No. 212. *"1907 Bean"* (Bolgiano). A medium-early, round green pod with mottled red seed.

No. 213. *"Mexican Bean"* (E. B. Voorhees). Spreading plants with dark green leaves, sending out runners, beginning to bloom (September 10th), with flowers white, pods of good size, flat, green, prevented from maturing by frost.

No. 214. *"Fordhook Bush,"* Lima. Plants are large, compact in growth, with an abundance of large, plump pods resembling "Dreer," but larger. The greenish white seed is large and plump, being shorter than that of the "Ideal Pole."

No. 215. *"Improved Bush"* Lima. This resembles the old "Henderson Bush."

No. 216. *"New Ideal Pole"* Lima. Strong growing, large-leaved plants, with large, broad, thick, curved pods; season medium early, large plump, kidney-shaped seeds, greenish white in color.

Government Beans.

U.S.D.A. 20002. The stand was poor and the late bearing plants had carmine-colored pods with mottled red seeds.

U.S.D.A. 20003. The plants were spreading with tendency to run, bearing long, flat, curved green pods, which were striped or tinged with red, and contained large "kidney" beans with longitudinal stripes.

U.S.D.A. 20004. The plants were open, spreading and inclined to "run," bearing long, curved, flat, medium-early green pods with white seeds.

U.S.D.A. 20396 This was an early bush variety with medium long, flat, curved green pods bearing mottled red seeds.

U.S.D.A. 20397. This was a late variety with flat, slightly curved green pods.

U.S.D.A. 20398. The plants were medium late, open and spreading with flat green pods of medium length containing pale yellow seeds.

U.S.D.A. 20399. These spreading plants bore flat, curved pods of medium length with white seeds.

U.S.D.A. 20900. These spreading plants had small leaves, following the "Mexican" type in habit of growth and late season. No blooms formed up to Sept. 9th.

U.S.D.A. 20901. This plant is similar to 20900 with a few white blooms.

U.S.D.A. 20902. This is another late spreading variety, not yet in bloom (Sept. 9th).

U.S.D.A. 20903. This variety resembles 20902 and not yet in bloom (Sept. 9th).

U.S.D.A. 20904. This is a good bearer, medium early in season, with a small crop of flat, curved pods bearing light grey seeds with a yellow "eye."

U.S.D.A. 20905. This variety conforms to 20904 in plant and pod types with black seed.

U.S.D.A. 20939. This plant is spreading in habit bearing a few flat, straight green pods.

U.S.D.A. 20940. The plant is spreading with white flowers and flat green pods forming Sept. 9th.

U.S.D.A. 20941. The plants are late with spreading habit and beginning to bear white flowers Sept. 9th.

U.S.D.A. 20942. These are upright bushy plants with large leaves, white flowers and straight, flat green pods.

EXPERIMENTS WITH HYBRID BEANS.

Hybrids between the "Scarlet Runner" upon bush beans were obtained in 1905 and seeds planted late the same year gave profuse blooming plants quite slow to produce seeds. The pods that did mature were much smaller than those of the male parent, *Phaseolus multiflorus,* and lacked the roughness characteristic of the pods of this ornamental climbing plant. The seeds (blend) obtained resembled the "Scarlet Runner" in being marked with red but were of much smaller size.

In 1906, thirteen plants were grown of the hybrid of the "Scarlet Runner" upon the "Tennessee," above mentioned, under the record fractional number of 63/43. The mother of the cross is a tall variety of bush bean with white flowers and long green pods that produce seeds of medium size and of a light brown color. The blend seeds for this crop were planted May 1st, and the results in seeds were shown in Plate XVII. of last year's report,

accompanied with a description of each lot. There was great variation in many respects, certain plants being nearly barren while others were prolific; no two had seeds alike in size, shape and color.

Plantings were made the present season from each of the thirteen lots of seed, and, at harvest time, the following among other notes were made:

B–1. The parent seeds were "solid dark purple," from which the following results, in terms of seeds only, were obtained: 7 black-seeded plants, 6 mottled dark, and 1 mottled brown.

B–2. The parent seeds were "yellowish brown with fine indistinct mottling," from which the following result was obtained: 1 white-seeded plant.

B–3. The parent seeds were "yellowish brown." From which were obtained: 3 plants mottled dark, 1 mottled grey, 1 white, 1 mixed (white, mottled purple).

B–4. This plant was large with red flowers and the most prolific of the set of thirteen grown in 1906. The seeds were borne close in the pods and angled at their ends and had a "grey color with fine bluish mottlings, becoming darker near the 'eye,'" resembling neither parent. From this set 32 plants were grown, giving in terms of seed characters the following tabular results: 10 grey mottled like parent, but no two plants were alike in this respect; 10 solid light brown; 9 white; 2 mottled dark brown, and 1 mottled ochre brown. Representatives of the types in this set are given in the upper row of piles in Plate XX., arranged from left to right as follows: B–4–1, B–4–2, B–4–11, B–4–21, B–4–26.

B–5. The parent seeds were "slightly mottled, with grey background." The following results were obtained: 2 plants with mottled seed.

B–6. The parent seeds "resembled blend type." The following results were obtained: 5 plants all mottled dark.

B–7. Failed.

B–8. The parent seeds "were similar to blend (mottled purple)," and yielded the present season: 4 plants with mottled seeds.

B–9. The plant is recorded as being large, spreading with purple flowers, etc. "The seeds making the second largest group were of good size and shape and uniformly of a dark purple color, appearing almost black." Of the 32 plants grown 18 were like the parent, dark purple; 7 white; 3 mottled purple like the blend seeds but smaller; 1 indistinctly mottled upon a seal brown; 1 motled dark brown; 1 mottled light brown, and 1 mottled dark with a white back. Samples of these same types of seeds are shown in Plate XX. under B–9–1, B–9–4, B–9–5, B–9–6, B–9–10, B–9–25 and B–9–28, respectively, the size of each pile showing the total output of the plant.

B–10. The parent seeds were "seal brown with purple blotches," from which the following results were obtained: 3 mottled purple; 3 white; 2 dark brown.

B–11. Failed.

B–12. This was a medium-sized plant with red flowers and short, flat pods, which matured early seeds that were mottled with dark brown upon a seal brown background. From this set 21 plants were grown with seeds as follows: 8 seal brown mottled, resembling the parent, but variable; 4 dark brown (almost black); 3 mottled dark brown; 2 light grey with brown "eye"; 2 indistinctly mottled light grey; 1 mottled grey, and 1 a clear light blue. Representatives of all these types are given in the lower row of Plate XX., arranged from left to right as follows: B–12–2, B–12–9, B–12–13, B–12–14, B–12–18, B–12–21.

B–13. The parent seeds were "dark purple with white end" and the following plants were obtained: 2 plants dark purple (approaching black).

From the Plate it is seen that there is great variation in the number of seeds that each plant produced. The set from B–4 is the most uniform in large output and kept up the record made by the parent, while the offspring of B–9 are remarkably variable. In shape no two are alike in the set shown for B–4, the smallest being B–4–1 and the largest B–4–11, but the contents are not well shown in the picture because some, as B–4–21, are very plump and the next pile to the left, B–4–11, has quite flat seeds. The same sharp contrast in size and shape is brought out in

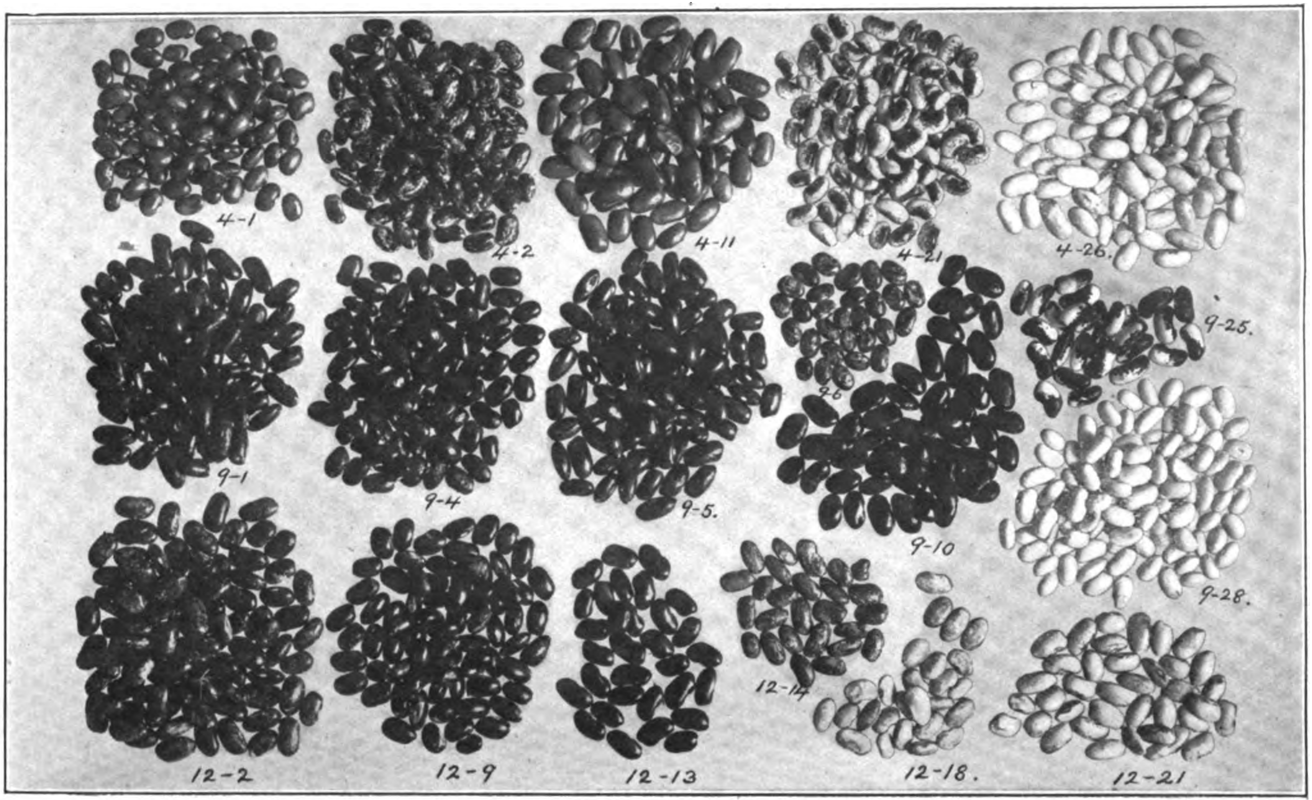


PLATE XX. *Hybrid Beans: "Scarlet Runner" upon "Tennessee."* The upper row shows representative types of B-4-1. Series; the middle row of B-9-1, Series, and the lower row of B-12-1, Series.

B–9–6 and B–9–10, where the former are nearly round and the latter flat as Limas and adhere closely to the "Scarlet Runner" parent. In the lowest row, B–12, the color is the most unlike visible character, for it ranges from a solid dark brown (nearly black) and solid blue through mottled browns and greys to seeds that pass for a dirty white with a brown "eye."

It is seen from a study of the offspring from the ten sets of plants that there is a showing of white in B–2, B–3, B–4, B–9 and B–12, or a full half, and a total of 18 plants with solid white seeds and several that carried very little color of any sort.

It is not the purpose here to account for this absence of color in the seeds of hybrids, the parents of which were far from white, but it may be said in passing that any color possibly may hide the character that, otherwise, might produce a white seed. Thus, in sweet corns, it is established that black or yellow grains may carry "white" blood that, in the next generation, will show itself when both parent germs are free from the color character. The "Scarlet Runner" has a white-seeded strain, and the seed used for the hybrids in question may have contained more or less of this white character, obscured by the mottled purple of the normal seeds. In like manner the light brown seeds of the "Tennessee" may have carried the same "tendency" to produce white; one or both of which suppositions would be enough to account for the white-seeded plants met with. There may be another principle in breeding that is at work here.

"Scarlet Runner-China Red Eye" Hybrid (63/9).

The hybrid above mentioned is now in the first generation after the blend, and the seeds from the nineteen plants are represented by the formula B–1, B–2, etc. Ten of the plants were early in fruiting, one medium early, two medium late, four late and two unrecorded, fifteen being of the bush type and four running or wide-spreading. In color of blossom the range was from white, (the largest number) through pale stripes, pink to salmon and purple. The pods were quite variable, upon some plants being short and flat, others long and curved, with or with-

out stripes. Among the seeds but little variety of form and marking prevailed. All were mottled and, therefore, showed no pure white seeds, and thirteen showed unmistakably the "Scarlet Runner" parentage in the flat, kidney-shaped seed and the dark purple blotches upon a lighter background of the same color. Three sets showed white upon the back, which may be due to the "China Red Eye," which has a white seed with a pink "eye." This latter character is not seen in any of the hybrids.

In this hybrid the type of plant follows closely the bush parent, but in the seeds there is a strong likeness to the "Scarlet Runner."

EXPERIMENTS WITH SQUASHES.

Summer Squashes.

Space does not permit of the full statement in tabular form of the results of the large area of summer squashes. From hand-worked fruits, either within the plant or the cross, of forty crosses grown in 1906, selections of seed were made this season of those that conformed to desired types with acceptable size and freedom from warts. Twenty-five rows of squashes were grown from seeds from close-fertilized fruits and twenty-three from those that had been pollinated within the cross.

The total number of fruits in the rows planted with close-fertilized seeds was 799 and in the rows with seeds fertilized within the cross, 804, giving an average of 32 fruits and 35 fruits per row respectively. The fruits in any row adhere more closely to parent type than last year.

From a study of the results, it is found that of the twenty-five sets of plants from close-fertilized seed but two showed any marked variation from the type of the parent fruit. Among the sets from seeds resulting from pollination within the cross but not within the plant, the conformity to type was somewhat less general. It is evident that the "Jug" type of squash is becoming fixed.

The "Strickler-Golden Bush" Squash Cross.

Among the fifty and more crosses grown upon the Home Grounds this season, no row excelled the above combination in the vigor and healthfulness of the vines and the number and large size as well as uniformity of the fruits. In 1905 the record shows that of this cross twenty-two plants were grown, all of them dark green and producing solid yellow (or orange) colored fruits with a broad neck, straight or nearly so, and showing but little wartiness. A study of the parents as to shape of fruit might lead one to project in advance the probable outcome of the union. The color of the two is so nearly the same that no change in this might be expected and the extreme flatness of the "Scallop" and the elongation of the "Strickler," which is not as "goose-necked" as the true "Crookneck," would suggest a form midway between them; and this is fully realized in the result. In length, the cross is not equal to the "Strickler," and along with the abbreviation there is the retention of the scallop features of the mother, but instead of this being a rim to the body of the otherwise oval fruit it assumes the nature of a series of long folds or corrugations that extend for some inches over the central portion of the fruit. It may well bear the name of "Fluted Orange."

Last year the report stated that the forty-two large, early, warty fruits of this cross were chiefly orange-colored and in type close to the parent, namely, an elongated "jug." The fruits this season have exceeded in length those of last year, and it remains to be seen whether they will hold to the type that is quite uniform in the row of eight hills now maturing.

The "Jersey Green" Summer Squash.

A strain from the cross of "Scallop" upon "Crookneck," after four years of selection, has become well fixed in shape and color, and seeds of it will be offered for distribution. The size and shape of the fruits are acceptable, being a long-neck "jug" of medium size, entirely without warts, and when ready for use are of a handsome, solid, dark green color.

The following table gives the percentage of flesh in fruits of the above-named commercial varieties and crosses of summer squashes:

	Large fruit.	*Medium.*	*Small fruit.*
"Crookneck,"	74%	....	81%
"Scallop,"	88%	....	87%
"Crookneck/Scallop,"	71%	....	70%
"Scallop/Strickler" (a),	81%	....	87%
four fruits,	80%	....	83%
"Scallop/Strickler" (b), three fruits,	83%	90%	86%
"Scallop/Strickler" (c), three fruits,	74%	78%	70%
"Fordhook" (a),	40%	....	50%
" (b),	77%	....	80%
"Cocozelle" (a),	78%	....	77%
" (b),	78%	....	73%
"Michigan" (a),	88%	....	66%
" (b),	88%	....	83%
Average,	77%	84%	76%

There is no marked difference between the percentage of flesh among the large and small fruits. The weights were not taken but the small were not far from a third of the weight of the large fruits. The following results were obtained of the number of seeds in large and small fruits upon the same plant:

	Large fruit.	*Medium.*	*Small fruit.*
"Crookneck,"	430	....	355
"Scallop,"	340	....	205 (immature)
"Strickler/G. Bush" (a),	325	....	255
" " " (b),	215	....	300
" " " (c),	245	....	280
" " " (d), three fruits,	280	230	375
"Crookneck//Scallop/Crookneck,"	360	....	265
"Crookneck/Scallop,"	165	....	280
"Scallop/Crookneck,"	550	....	515
"Crookneck//Scallop/Crookneck,"	285	....	365
"Scallop/Strickler" (a),	425	....	360
" " (b),	425	....	450
four fruits,	390	....	405
"Scallop/Crookneck" (a) three fruits	250	65	350
"Scallop/Crookneck" (b) three fruits	70	360	455
"Fordhook" (a),	200	....	120
" (b),	155	....	280
"Cocozille" (a),	285	....	130
" (b),	450	....	360
"Michigan" (a),	205	....	85
" (b),	180	....	350
Average,	297	218	311

The number of seeds is practically the same for the large and small fruits. In three instances, where three fruits from the

same vine were seeded, the number of seeds increases from the oldest to the youngest as 166:252:460.

As to the relation between size of fruit and that of the seed, it was found that the large fruit gave larger seeds than the small fruit in every instance.

Summer Squashes New to the Home Grounds.

Three commercial varieties of summer squashes were grown upon the Home Grounds the present season, namely, "Fordhook" (51), "Cocozelle" (52) and "Michigan" (53). The first two had failed in attempts to raise them in previous years.

In the "Fordhook," one has a small, early bush variety that bears small cream-colored fruits, approaching in shape type No. 15, which is a ribbed "jug" without warts, and less elongated at the base. This variety has a fine, thick flesh and may prove a desirable parent in some of the crosses that have been secured with it.

The "Cocozelle" is a strong-growing sort with heavy vines, quite inclined to "run" and bear freely the very large elongated pear-shaped fruits that are nearly solid green when young, but take on ribs of orange at maturity. The flesh is not firm and the quality only fair, but there are qualities of plant and fruit that give hope for better things in the crosses to be expected with it next year.

The "Michigan" is a true vine squash that made it seem out of place among the bush sorts. The fruits are long and slender, like huge cucumbers, but with a peculiar lead color. In quality, it was variable, doubtless depending upon the age of the fruit when used for the table; gathered when two-thirds grown, it proved acceptable and, producing squashes throughout the whole season, this kind may be highly prized by many. It crossed readily with the regular bush varieties of its species, and possibly some new types of bush and vine summer squashes may result therefrom.

Winter Squashes.

The winter, and all vine, squashes were assigned to the Smock Land, where a large area was devoted to them and a long list

of commercial sorts, not before grown by the Department, was added to that of the crosses previously secured. Soil and season conditions were not favorable for a satisfactory crop, and whatever is given below concerns plants and fruits that were not up to the average in vigor and size.

Relative Amount of Flesh in Squashes.

A study of the flesh content of vine squashes in particular has been begun as a factor in the advance toward better fruits. The method of determination consisted in plunging the squash (first washed of all adhering soil) into a tall vessel filled with water to the brim and catching the water of displacement in a dish into which the tall jar had been set. This water thus overflowing was weighed and later, in a similar manner, a corresponding record was made of the water displaced by the two halves of the squashes, held side by side, after the seeds and worthless shreds (plasentæ) has been removed. The weight of the water displaced by the two halves, divided by that of the whole squash, gives the percentage of the flesh; thus, should the displacement of the halves be 75 ounces, and 100 ounces be that of the whole squash, it is evident that the seed cavity makes up 25 and, therefore, the flesh is 75% of the whole fruit.

The value of a summer squash, that is, its amount of food, is not measured entirely by the flesh, for with these the whole fruit is cooked with the exception of the skin, which is often removed when the fruit is somewhat advanced in age. It is, however, true that the part of greatest value is the flesh, and a variety may be best that has the largest percentage of flesh and, therefore, as one method of improving this vegetable fruit means are being taken to increase the percentage of the wall of the fruit and, therefore, reduce its often large contents.

With the winter squashes the case is clear that a fruit with a thin flesh has far less food than another of the same size with a thick flesh. It is still to be shown that there is any correlation between the thickness of the flesh and its quality, but, from the standpoint of quality, the thin-fleshed squash is ruled out.

The following are the results that were obtained by the "hydrometric" method described:

STATISTICS OF WINTER SQUASHES.

KIND.	Relative size. L—large. S—small.	Weight of whole squash—lbs.	Weight of flesh in lbs.	% weight of flesh.	Thickness of flesh in inches.	Volume of flesh in percentage of whole.	Number of seeds.
"Warren" (7),	L	9⅝	9⅛	95	1¼	81	180
	S	6¼	5¾	92	1	80	330
Hub/B. Marrow //.	L	7½	7⅛	95	1 1/16	81	425
Delicious/G. Hubbard (1/2//3/4),	S	5⅛	4⅝	85	1 5/16	90	330
	L	8½	8	94	1⅛	79	245
	S	6	5⅛	92	1	79	225
"Delicious/Hubbard" (3/1),	L	6⅝	5⅞	92	1	72	300
	S	3¾	3¼	87	¾	73	270
	L	7½	6¾	90	1¼	78	320
	S	3¾	3⅝	90	1	78	275
	L	6½	5⅞	90	1½	74	475
	S	5½	5	91	1⅛	78	560
	L	5½	5	91	⅞	71	390
	S	3⅝	3⅛	86	1	71	485
	L (I)	2⅝	2⅜	90	⅞	78	200
	S (II)	2¼	1 15/16	86	¾	75	170
"Delicious/G. Hubbard" (3/4),	L	6	5¾	96	1	76	220
	S	3⅛	2¾	88	¾	76	220
	L	4½	3⅞	91	1	80	165
	S	2⅝	2⅛	81	⅞	77	240
	L	6¼	5¾	92	1¼	76	330
	S	3¾	3⅜	90	1	74	60
	L	5¼	4½	86	1	70	430
	S	2⅞	2½	87	⅞	81	250
	L (I)	5⅞	5⅛	87	⅞	66	320
	S (II)	2⅞	2½	87	¾	77	275
"Delicious/Warren" (3/7),	L	5⅞	5⅛	87	1⅜	77	345
	S	3⅝	2⅞	79	⅞	68	80
"Hubbard/Delicious" (1/3),	L	4⅛	3⅝	87	1	76	285
	S	1⅞	1⅝	87	⅝	78	145
"Cocoanut" (19),	L	¾	11/16	96	¾	81	165
	S	⅜	5/16	90	½	82	65
"Delicata" (32),	L	3⅛	3	96	⅞	80	145
	S	1⅝	1½	92	¾	73	260
	L	⅞	13/16	93	9/16	71	150
	S	⅜	¼	67	½	99	55
"Perfect Gem" (43),	L	15/16	⅞	98	¾	82	285
	S	½	7/16	94	11/16	84	150
"Fordhook" (38),	L	1⅓	1¼	97	11/16	84	210
	S	11/16	10/16	94	⅝	84	155
"Michigan Mammoth Pumpkin" (48),	L	10¾	9⅞	92	1⅛	80	580
	S	4	3⅝	91	1	70	465
"Field Pumpkin" (46),	L	13	12½	96	1½	73	640
	S	11¾	11	94	1⅜	73	560
"Sugar Pumpkin" (49),	L	6⅞	6¼	91	1⅜	77	500
	S	2⅞	2⅝	88	1⅛	78	480
"English Vegetable Marrow" (36),	L	3⅛	2⅝	84	⅝	62	225
	S	1⅝	1½	92	⅝	77	210
"Italian Vegetable Marrow" (41),	L	4⅝	4¼	92	¾	77	485
	S	2⅛	1⅞	90	½	76	160
"Winter Crookneck" (18),	L	10	9	90	1	82	415
	S	4	3½	87	½	87	215
	L	8¾	8⅝	96	.....	80	.....
	S	5½	5	91	.....	82	.....
	L	9¼	8¾	95	¾	77	390
	S	6⅞	6½	95	¾	80	350

The data presented above may help in comparing the different varieties of squashes. The soil where the squashes grew was very poor, consequently none of the plants were at their best.

While there are exceptions, the table above shows that, in general, the larger fruits (marked *L* and alternating with *S* for small) within the variety have the larger percentage of flesh as compared to the whole weight of the fruit; it also shows that the percentage of flesh in volume as compared to the whole squash varies with the thickness of the flesh.

The squashes in the above table can be divided into the following groups: (*a*) the true *Cucurbita maxima;* (*b*) the small *C. Pepo,* like "Cocoanut," "Perfect Gem;" (*c*) the large *C. Pepo,* like the true pumpkins; (*d*) the long *C. Pepo,* like the "English Vegetable Marrow," and (*e*) the *C. moschata.* The percentage of flesh is highest in group *b* and followed in order by *e, c, a* and *d.* Likewise, the solidity of flesh is highest in *b* and followed in order by *e, a, d* and *c.*

A study of the numbers of seeds shows that, with five exceptions out of thirty-four instances, the larger fruit contains the greater number of seeds; furthermore, the seeds of the latter are larger. In other words, the larger of the two squashes upon the same vine contains the larger seeds, and generally more of them.

In Plate XXI. is shown ten pairs of samples of squash seeds. The ten seeds from the smaller squash of each pair from the same plant are placed, in each case, to the right of those from the larger fruit, and the record number below the pair shows what variety or cross is represented.

At 3/1 is the set of the "Delicious/Hubbard" cross, and the difference in size is evident. There are two sets of the "Delicious/-Golden Hubbard" (3/4) cross and, in addition to the difference in size, there is a marked variation in shape. The next, "Winter Crookneck" (18), is a representative of the *Cucurbita moschata* with a decided change in the type of seed, but here the rule is regarded that the smaller fruit has the smaller seed. In the "Cocoanut" (19) the fruits are, at best, very small and the larger yields the much larger seed. The "Fordhook" (38) shows seeds similar to the last with the result as to correlation of size of fruit to that of seed fully maintained. At 41 is the representative of "Italian Vegetable Marrow;" at 43, "Perfect Gem," and at 48, "Michigan Mammoth Pumpkin," three of which show

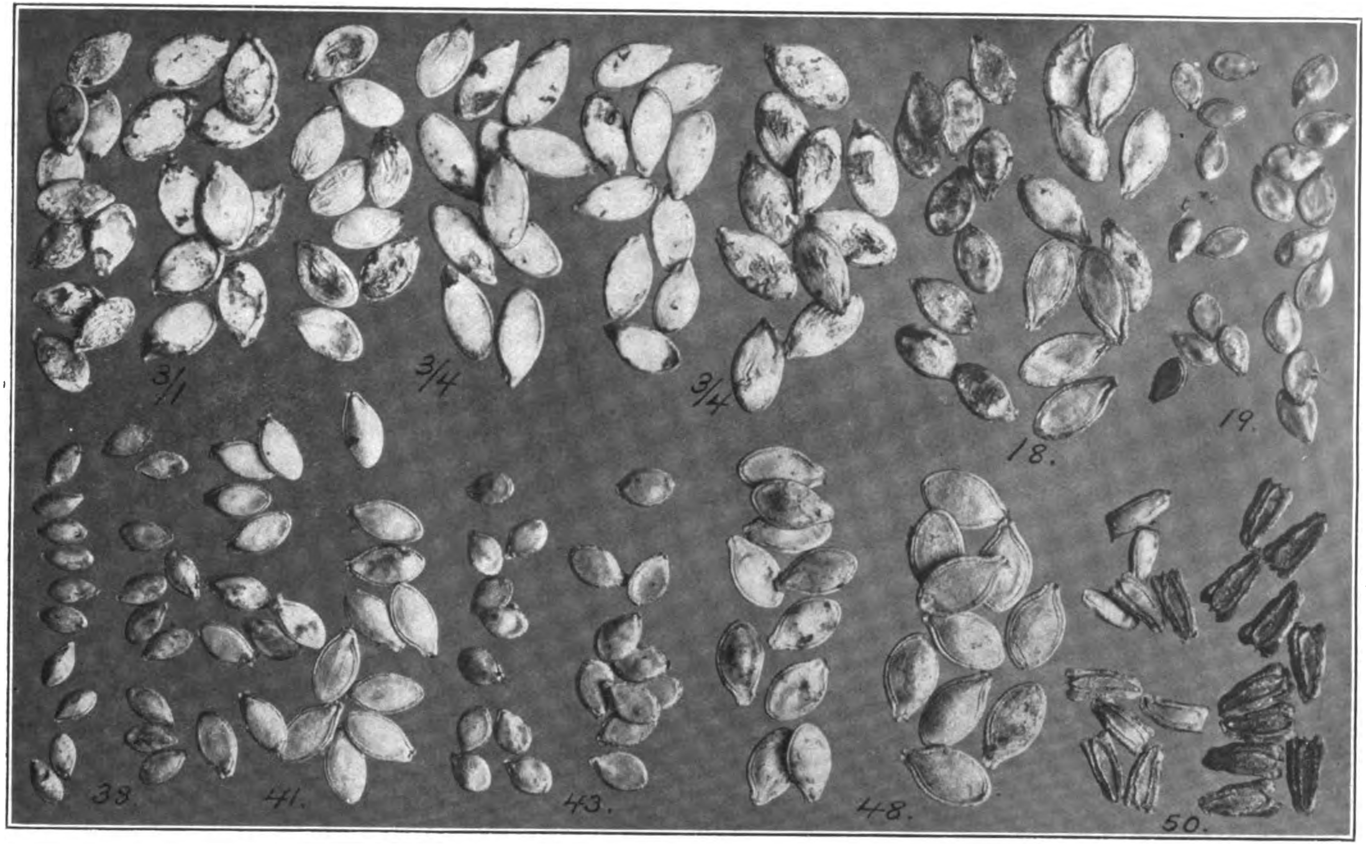


PLATE XXI. *Squash Seeds.* Sets of ten seeds each in pairs from large and small fruits of same kind, showing that the larger squashes produce the larger seeds.

a wide range in size, but the same correlation. The last pair of ten seeds is of a gourd, "Chinese Bottle Gourd" (50), in which the seeds are smaller from the smaller fruit as shown elsewhere.

Out of thirty-four instances examined there were only four exceptions, and in these the size of the seeds was either practically alike in the two fruits or only a slight variation from it.

In connection with the thickening of the flesh the problem of seed content is not to be overlooked, and facts are to be sought that may throw light upon the improvement of the variety, both in greater percentage of food in the fruit and vigor of the plant that produces it. In other words, the selecting for thick flesh may, in a measure, be a selecting of the fruits with low seed content, and a fruit that produces but few seeds may give them better conditions for a superior development that shows itself in stronger plants. An inverse correlation may exist between flesh content and seeding capacity, which carried a step further may mean better equipped plants from the seeds of thick-fleshed fruits.

Reports from Testers for Station Winter Squash No. 2; Delicious—Bay State (3/21).

"Have seven healthy plants." "Foliage is heavy, fruits assorted sizes and colors and of various shapes, oval; pointed at one end; flat and round and some slim and tapering. Colors vary from drab, dark green, to light green and yellow. One is now ripe and is of a reddish tinge. It was yellow when growing. Fruit is now setting in abundance." "Vines made a rank growth, fruit set fine, color light green. Shape like a bowl." "Germinated well. Plant vigorous. Fruit plentiful in numbers and quite uniform in size." "The plant is good size, quite productive." "My winter squash is very nice and productive, as many as ten squash on a plant of good size and uniform color." "The vines are very productive, spreading quite a distance and bearing fruit of medium size." "Color yellow, shape almost round, some oval, doing well." "It did very well, medium size and vigorous grower." "Very hardy and productive. Made a good growth where 'Hubbard,' grown on same ground, failed on account of borer and adverse weather conditions." "Squashes were not very large but nice size for small family; the quality is fine, much like the 'Hubbard.'" "The squashes are both long and flat in shape. The vines are quite productive, although the squashes are all

very small, about two to four pounds each. Quality first class, very sweet, dry and fine-grained." "Size small, a very vigorous grower and very productive." "Flesh deep yellow, very thick and made excellent pies." "Healthy vine, very prolific, small fruits, solid, small seed cavity, extra fine quality." "The winter squashes are the finest I ever had, grew to a fair size, all uniform and a good color. I am much pleased with them."

Varieties of Winter Squashes Not Before Grown in the Gardens.

No. 34. "Chicago Orange Marrow." Resembles the summer "Crookneck."

No. 35. "Chiloe, or Sugar Squash." All plants died before bearing.

No. 36. "English Vegetable Marrow." Fruits long or oval, light yellow or striped.

No. 37. "Faxon's Brazilian." The "Hubbard" type, green, yellow or orange.

No. 38. "Fordhook." Resembles the summer "Fordhook."

No. 39. "Green Mountain." No crop.

No. 40. "Heart O' Gold." No fruits matured.

No. 41. "Italian Vegetable Marrow." Fruits long, dark with green stripes.

No. 42. "No. 94." Fruits not uniform in shape, all lead-colored.

No. 43. "Perfect Gem." Like "Cocoanut," but have no stripes.

No. 44. "Sibley, or Pike's Peak." Fruits like "No. 94" in form and color.

No. 45. "White Congo." No crop.

PUMPKINS.

No. 46. "Field Pumpkin." Large, long or oval, orange-yellow.

No. 47. "Mammoth Red Etampes Pumpkin." No crop.

No. 48. "Michigan Mammoth Pumpkin." Large, spherical, reddish-yellow.

No. 49. "Sugar Pumpkin." Medium size, but resembles No. 48 in other respects.

No. 54. "Sweet Potato." Large and very long, dark with green stripes.

No. 55. "Mexican Pumpkin." No crop.

GOURDS.

No. 50. "Chinese Bottle Gourd." As the name suggests, its shape is like a bottle.

EXPERIMENTS WITH PEAS.

Several sets of pea crosses that had been carried through their first generation from the blend plants last autumn were continued during the spring months. A large part of the details of these trials will be left in the record books for the present, but something concerning a single combination is noted below.

Second Generation of "French Canner-American Wonder" Cross (41/4).

Following the tentative classification of the one hundred and twenty-seven seeds of one of the plants of this cross, peas were planted of the eight combinations given below:

Smooth;	Cream,	Large.
Smooth,	Cream,	Small.
Smooth,	Green,	Large.
Smooth,	Green,	Small.
Wrinkled,	Cream,	Small.
Wrinkled,	Cream,	Large.
Wrinkled,	Green,	Large.
Wrinkled,	Green,	Small.

At harvest time, all eight groups were represented excepting the last one, of which there were only two seeds at the outset. The record shows that the dwarf plants were limited to two with one that showed a form and size midway between the dwarf and standard plant. This is far below the number expected under the Mendelian rule, but, as the harvested plants were only twenty-four, the number is too small for any close approximation. It is found that peas are not an easy subject for the study of seed char-

acteristics when the whole output of a plant is included. For example, the question of size, color and smoothness are decidedly modified by age, and when any pods are even a little immature the peas are classified with difficulty. Much more work is needed to warrant any conclusion as to whether size is among the unit characters. There seem to be several, for example, as to size, shape, form and color of pods.

In the cross in question, the "American Wonder" is a dwarf variety with medium-sized pods and large, green, much wrinkled seeds, while the "French Canner" is a standard sort with slender stem, bearing small pods and small, light or flesh-colored smooth peas. The contrasts are many, and the cross, therefore, involves striking differences.

So far as the whole plant is concerned, the "French Canner" has controlled the size, and a large plant, as a rule, may be expected from the cross with only an occasional dwarf plant (possibly one in four) appearing among the offspring of the standard plants. In the size of the pods, the "American Wonder" has had a very marked influence, but the data are too limited for the exact value of each parent to be determined for the present.

The eight plants that grew from wrinkled seeds all produced wrinkled seeds without exception. In the set in this group, in which the seeds were cream colored, there were 75 green seeds in the total of 408 peas, and from the two plants grown from green wrinkled peas, the seeds (76) were all green, but the shade differed strikingly in the two plants, although constant in the respective plant.

Of the sixteen plants grown from smooth seeds, one was weak, and its seeds were rejected. The following results were obtained from the test:

Smooth,	Cream,	Large,	114
Smooth,	Cream,	Small,	107
Smooth,	Green,	Large,	125
Smooth,	Green.	Small,	2
Wrinkled,	Cream,	Large,	21
Wrinkled,	Cream,	Small,	5
Wrinkled,	Green,	Large,	34
Wrinkled,	Green,	Small,	0

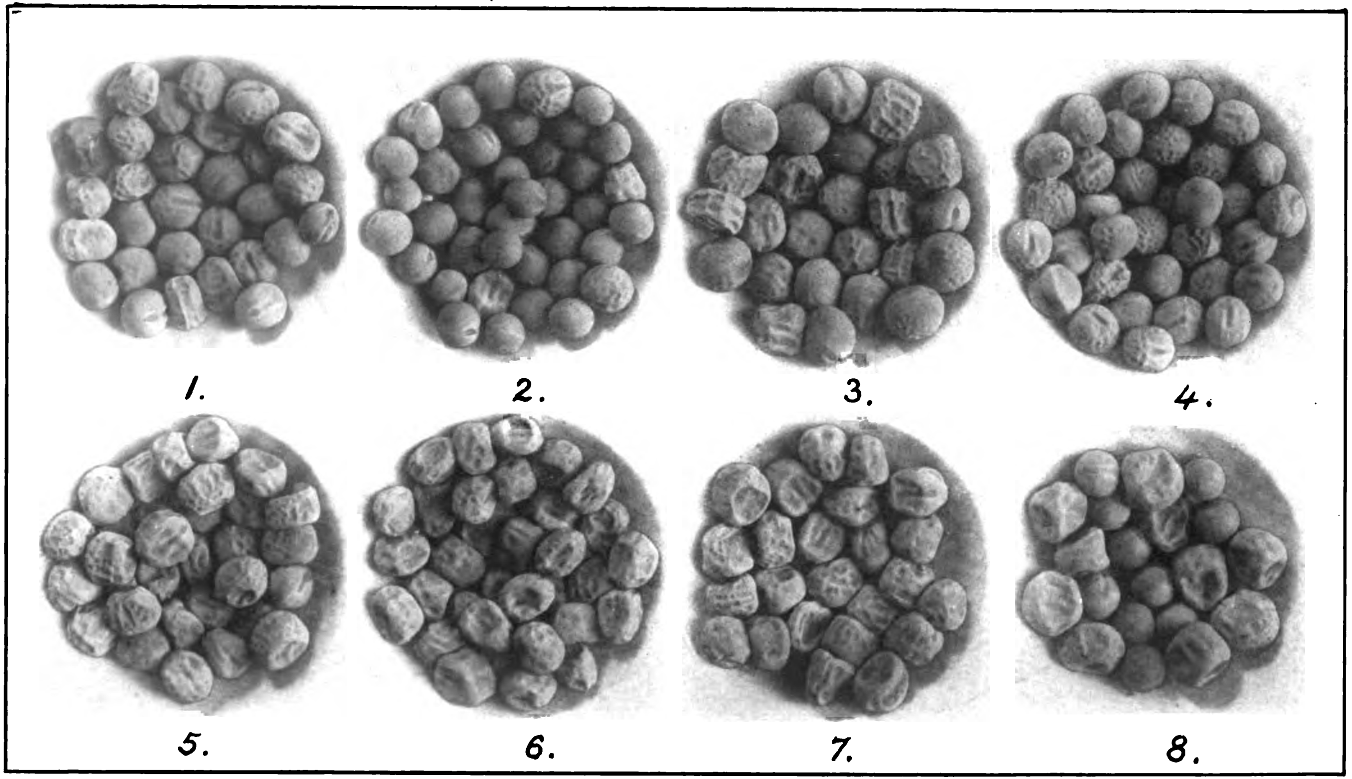


PLATE XXII. *Crossed Peas.* Several combinations of "French Canner" upon "American Wonder" are shown in the first seven pits of the artist's dish, with both the parents, represented by ten seeds each, at 8.

Disregarding the size on account of the difficulty of discrimination, the table is reduced to:

Smooth,	Cream,	221
Smooth,	Green,	127
Total,		348
Wrinkled,	Cream,	26
Wrinkled,	Green,	34
Total,		60

In Plate XXII., the seeds from a plant grown from a smooth, light, large pea are shown at 1; they are of average size and both smooth and wrinkled, light and green. At 2 is a similar set from a smooth, light, small seed and it is observed that the size is decidedly less than in any other dish in the plate; the smooth peas being easily mistaken for the pure "French Canner," samples of which with the other parent of the cross are shown at 8, ten of each. At 3 is a sample of the result of a smooth, green, large pea and all the seeds are green and large but the smoothness is not so apparent as in the previous dish. At 4 are the seeds representing the output from a smooth, green, small seed and it agrees closely with that for dish 3, all being green but somewhat smaller.

At 5 is shown a sample of seeds that came from planting a wrinkled, light, large seed and it is seen that the peas are all wrinkled and large with twenty-five per cent. of green seeds. The next dish (6) contains peas resulting from the planting of a wrinkled, light, small seed and the set photographed is practically the same as that shown at 5, with some diminution in size. The set at 7 is from a wrinkled, green, large pea and all the offspring resemble the parent fully. At 8, for purposes of comparison, the two parents of the cross are given.

It is too soon to predict the possibilities of this combination, and the lines to be followed further depend upon the end sought. If one desires a small seeded early plant, it may come out of the lot represented in dish 2, when the wrinkled peas will give a truly sweet sort and, if the size is the main thing as with some growers for the canneries, the smooth peas may give the desired end,

namely, a prolific quick-growing kind that yields its small peas all at once to accommodate itself to the modern method of harvesting with a thresher. For home use, it is possible that an acceptable sort may be derived from the lower row of dishes, especially should the plants be half-way standard or medium in size and not require brush or trellis.

Autumn-Grown Peas.

The less said the better is one way of considering the growing of peas during autumn. A block of thirty-two hills was planted to peas after the removal of a crop of "Malamo" corn in August. While aware that peas did not like the hot weather of midsummer, there was hope that by the time seedlings were in their first leaves, the cool nights and shorter days of autumn might bring a crop and thus add one generation to the cross. The peas used for planting were freshly grown in a spring crop near by, and consisted of the second generation from the blend of "French Canner" upon "American Wonder" (41/4). Nineteen hills received smooth, cream-colored seeds; six received wrinkled cream-colored; four, smooth, green, and three, wrinkled green seeds.

As before stated, the "French Canner" is a tall, slender, late variety with small, smooth cream-colored seeds, while the "American Wonder" is a dwarf early type, bearing comparatively large, wrinkled green, or "bluish" peas. The following table gives the results as to size of plants, the crop being so small as to be a negligible quantity:

	Dwarfs.	*Standards.*	*Medium.*
19 hills,	17	25	14
6 "	4	9	3
4 "	2	2	1
3 "	2	3	2
32	25	39	20

Even with the "medium" being included with the "standard," there is a high percentage of the "dwarfs."

A second block of ground (where thirty-two hills of "Malakosby" corn had been harvested) was planted with peas at the

same time as the one above noted but the crosses here were different and no crop was secured.

A shade experiment was made with a few hills of peas by placing them between widely separated over-arching trees, but only an occasional seed was the reward. The hope of growing peas to a liberal fruiting, other than in the spring, hangs by a slender thread and work with other crops in midsummer is too pressing to spend time in nursing any one kind unduly out of season.

EXPERIMENTS WITH SALSIFY.

Upon August 25th (1906), the following rows of three hills each (four by four feet each way) were planted in the lower part of Plot 4, Series II.:

Row 1. This was planted with seeds formed under bags of the pure yellow wild type (*Tragopogon pratense*). The plants all came true.

Row 2. This was planted with seed from protected heads of darker red orange (Prang, No. 31), and the plants produced a set of blooms of the same color combination.

Row 3. This set of three hills was planted from bagged heads of plants of 21–y, dark red red orange and reproduced the parent type with much uniformity.

Row 4. This row contained plants fertilized within the head of the red violet (No. 233), which adhered closely to the parent color with some "yellow-eyed" heads.

Row 5. The plants here were somewhat variable in shade but within a narrow range and proved no marked exception to the rule.

Row 6. This was a duplicate of row 5.

Row 7. This set of hills was planted with seed from protected flowers of the light red violet (No. 234) type and came true to the parent color.

Row 8. This row was planted with "suspect" seed of garden upon "Black" salsify, but all the plants were of the latter species.

Row 9. This was an attempt to get a reciprocal of the last-named, but all the plants were the pure garden type.

Row 10. Here an attempt was made to breed the "Black" upon the wild species but the result was a failure.

Row 11. This row was occupied with a set of the "Black" salsify for the purposes of further attempts at breeding.

The test of the present year illustrates that close breeding, that is, within the plant and more within the head, is sufficient to perpetuate the particular shade of the parent among hybrids that have been selected somewhat at random from many color types.

The union of two species of salsify, both with very uniform and widely different colors of the bloom, results in the production of a great many shades in the flowers of the hybrids. It seems probable that any one of these may be fixed with much ease by simply limiting the fecundation to the plant carrying the shade it is desired to perpetuate.

Because of the unusual difficulties that have beset the experiment from its beginning some years ago and the lack of direct practical results the work with salsify is for the present set aside. Anyone, however, who wishes to make a study of the floral colors of hybrids can find few better species for that purpose than the wild and garden salsify, provided the weediness of the crop is no disadvantage and birds can be kept from the plants at the time when the heads are maturing their fruits.

EXPERIMENTS WITH OKRA.

The plan was laid to grow a full set of the okras the present season and begin a systematic breeding of the various kinds, a classification of which was given in the last report (pp. 501, 502), but the seeds gathered in from various sources quite generally failed. One is not certain of what he has as a basis for breeding operations in truck crops until he has tested it for some years, and this seems to be particularly true with okras. It is possible that the usual care taken by the best seedsmen to have their goods true to name does not bring the desired results with okra, and it may be that the plants themselves are largely at fault. The subject certainly demands study, as it does more consideration from the hands of the practical grower. Be this as it may, the

work upon the plot of okras the present season casts a doubt as to the reliability of the names of some of the parents, and, therefore, upon the real significance of many crosses that were secured. The "Dwarf Prolific," for example, was a standard, and "Lady Finger" had pods ranging from very short to long.

A photograph was taken of four kinds that were represented by several plants each, namely, "Lady Finger," "Perkin's Long Pod," "White Velvet" and "Kleckley's Favorite," but it seemed best to withhold it from publication until a better representative set could be secured.

"PAK-CHOI" AND "PE-TSAI."

These quite similar Chinese vegetables were grown somewhat extensively in the Home Grounds in 1906 and reported upon with a plate last year (Plate XXV.). Seed was saved from some of the plants and distributed to several growers of truck crops for a practical test.

The reports which follow are generally to the effect that the plants are quick-growing and hardy and are inclined to "run to seed." From our limited experience, this is true of the early crop, but when the seed is sown in midsummer the plants make large development of the edible leaves without any show of flower stalk. The "Pak-Choi" is very resistant to frosts, and, at the time of writing (November 1st), large plants are in full vigor in spite of cold nights that produce much ice. It is as a late autumn crop that this vegetable is of greatest use, and, as such, shows much merit. It does not seem to be attacked by the ordinary enemies of Brussels Sprouts and its cabbabe-like allies.

Reports from Testers for "Pak-Choi."

"Vigorous and productive. At this writing (Aug. 14th) plants average eighteen inches high, and a few are just running to seed, or rather beginning to bloom. Planting was not made until June 15th. In early stages or when blanched, is fairly good for salad, or passably good boiled for greens, its quick growth being in its favor." "Plants about twelve inches high, of rapid growth." "Growth rapid, leaves light green." "This seed was planted

early and has now gone to seed. It grew rapidly and was thrifty, and has a considerable quantity of seed." , "Weather conditions extremely bad, cold, dry, or very cold rains. 'Pak-Choi' seemed to thrive, however, when other things stood still." "The plants are strong and vigorous." "The plant is with us very vigorous and productive. We grew it on muck ground. The unused plants are now ripening seed. We have a summer boarding-house. Our boarders were pleased with this vegetable and generally voted that in flavor it was suggestive of Brussels Sprouts. We served it in a cooked state." "Height about twelve inches, quick grower. Volunteer plants have come up from seed self-sown." "A very vigorous plant." "Found 'Pak-Choi' very hardy, thrifty and a strong grower." "Planted June 11th, first mess July 22d, when it was already very large. It perhaps has its place being very hardy, thrifty and of quick growth but I cannot say that we care for it."

Reports from Testers for "Pe-Tsai."

"Growth very vigorous, four to five inches tall when in seed. Root, of turnip shape, about two to two and a half inches largest diameter, and perhaps three to four inches long to tip. Flavor resembling kohlrabi." "Large size and vigorous growing plants, two or three crops can be grown on some ground in one season and large crops. "Twenty inches high, well leaved out, seed very fertile, plants thrive when wet and grow slowly but healthfully when droughty." "Similar in form to 'Pak-Choi.' " and makes a good 'Greens' not as thick-leaved as 'Pak-Choi.' " "In regard to 'Pe-Tsai,' the plants were set out on the 15th of May and were not affected by frost. The plants matured the first week in July Height about eighteen inches, width of leaves four inches. In going into seed, it measured thirty inches in height. In preparing for the table, it tastes like 'Swiss Chard' or spinach." "This grew well on my grounds and I found the greens a very welcome addition to the bill of fare, both cooked, and green. I shall have plenty of seed to plant more extensively next season and look for even better results, as this year has been a very trying one for all vegetables, and anything that did even half well under such unfavorable conditions has certainly proved its value." "Identical in every particular with 'Pak-Choi.' Growth vigorous to six or eight leaves, then big seed stalk; used younger leaves for cooking, two or three picked from each plant." "Grows about five feet high, only two plants thickened to a head, but grew up at once to seed. Of the two that headed one was cut and has formed a group of heads. The plant is a vigorous grower and of good

flavor." "It has large leaves, broad and eight or ten inches long, tops long." "Came up well and grew very luxuriantly, tender and fine. Some of it grew to the height of four feet." "Large, vigorous, much like mustard." "Made rapid growth and when four inches high was tied with raffia to bunch. Made a fair table salad." "A very vigorous, hardy plant and should be a valuable acquisition."

EXPERIMENTS IN THINNING.

As an aside from the regular work, some tests were made in thinning. For example, one plant in each of the eight hills of a row of "Kelsey" and of the "Station" Bush Lima beans had a half of its pods removed while they were small, the older pods only being retained. These plants were not in any way selected, but in all respects seemed to be an average set, and they gave the following results:

	Weight of Pods.	Weight of Seeds.	Number of Seeds.
"Kelsey"—			
Thinned plants average, ...	2.25 oz.	1.25 oz.	50
Normal " "	1.73 "	.97 "	48
"Station"—			
Thinned plants average, ...	6.00 oz.	2.50 oz.	60
Normal " "	5.20 "	1.67 "	46

It is seen that the results are decidely in favor of the thinned plants, the weights of seeds being in the ratio of 375 to 264, or a gain of more than one-third. There was a gain also in a larger percentage of mature seeds, but, as it is practically impossible to separate the mature from the green seeds, the exact figures in this respect are not at hand. The number of seeds was larger in both cases for the thinned plants, but the cause is the same here as elsewhere, as, for example, when orchard fruits and other kinds are thinned. The plant, left to its own devices, was not able to hold as many pods as where a half or less received the motherly attention that was elsewhere divided among a great number. It is likely that the thinning of the plants for the production of the seeds for future plantings might result in profitable results, but in general field culture the process is not expected to be employed.

A set of plants of "Hyacinth Bean" *(Dolichos Lablab L.)*, which grew with great vigor and bloomed most profusely, offered an opportunity to test the effect of thinning, but, in this instance, within the single flower clusters which normally may mature eight or more pods, as shown at 1 in Plate XXIII. In the thinning sometimes the oldest (lowermost) bloom or young pod was left as at 2, or the middle one as at 3, or the youngest as at 4; in the last, however, a middle pod was also reserved. One of the most noticeable features with this test was the hastening to maturity of the isolated pods; thus, upon two similar clusters, one thinned and the other not, the pod upon the former became dry and the seeds hard before the normal cluster showed any signs of maturity. At 12 is shown an instance where the flowers were all removed from the main axis and afterwards a short stem formed below, which bore five large pods. In 15, the flower buds at one joint only were left and these developed into five large pods, where normally one or two are produced; in other words, the natural thinning probably was interfered with.

There does not seem to be any increase in the size of the pods or weight of the seeds ascribable to this process of thinning and the relative strength—vigor, variability, etc.—of the seeds thus produced is a matter for later consideration.

EXPERIMENTS IN GRAFTING.

During the past winter, some attention was paid to grafting among vegetables in the greenhouse. The methods consisted in growing two plants near together in the same box, or in separate pots, and at a foot or so above the soil, a "tongue" was made on each plant by a slant incision into the stem, the one upward and the other downward, the two then being united by mutual insertion and the joint covered with moist moss and tied with raffia. In this condition, the two plants were allowed to remain until the joints grew together, and then the plant selected as the scion was cut off below the union. The resulted graft, trimmed of its unnecessary parts, was kept erect by fastening to a support.

PLATE XXIII. *Hyacinth Bean.* Illustration of the effect of thinning within the Flower Cluster.

While no definite statement can be given as to the ages of the plants grafted, the rule was to have the plants old enough to withstand mutilation and yet young enough to insure rapid union.

Tomato upon "Garden Huckleberry" (*Solanum nigrum*). The attempts gave one success. The graft rapidly increased in height, but its foliage was scant. It was set out in the field where it lived until the middle of August, having time to produce one fruit which was an inch in diameter. The seeds were many, and when started grew vigorously. No effect of the "Huckleberry" stock was noted.

'Garden Huckleberry" upon Tomato. Two attempts gave one success. The graft was vigorous and, when set out in the field, it grew until the autumn frosts. The scion and stock both produced an abundance of their own kind of fruit. Seeds were many in every fruit and produced seedlings rapidly. No effect of tomato stock upon "Huckleberry" was noted.

Tomato upon Eggplant. Two attempts gave no success.

Eggplant upon Tomato. Two attempts gave one success. The graft at first was not vigorous, but when set out in the field it grew well and matured many tomato fruits and one eggplant fruit; the latter was small and its seeds started well. No effect of eggplant upon tomato was noted.

Tomatoes: Fine-Leaf and Coarse-Leaf. Eighteen attempts were made to graft tomatoes: Nine fine-leaved upon coarse-leaved, and nine reciprocals. While all the grafts started, two were weak and died within a month; only nine out of the sixteen were fit to go into the field and, within a week, two died, leaving seven grafts that grew vigorously throughout the season. These grafts represented five coarse-leaved upon fine-leaved, and two reciprocals. Only one graft-plant (a fine- upon a coarse-leaved) showed the effect of the union; the leaves from stock and scion were the same and not as coarse nor as fine as the foliage of the original parents.

SMALL CAPSULES WITH HYBRID SEEDS.

A few plants were grown of three species of Daturas, namely, *Datura Stramonium, D. Tatula* and *D. Meteloides* for purpose of hybridization.

Shortly after the floral parts fell away, it was noted that the capsules that were resulting from the pollination of the *D. Meteloides* upon either *D. Tatula* or *D. Stramonium* were much less rapid in growth than those that were pollinated in the open. This difference continued to increase until the time of harvest when the capsules from flowers treated with *D. Meteloides* pollen were only a quarter or less the size of the others upon the plants. In Plate XXIV., seven branches are shown, five upon the left of *D. Stramonium* and the two to the right of *D. Tatula*. The capsule with the label, in each case, is from the hand-worked flower and those nearer the tips of the respective branches were formed later. The comparison should be made with the largest of these younger capsules and this will show that there is quite a uniform difference as above mentioned.

The seeds were very few in these small capsules; thus, of the *D. Stramonium*, one had no seeds; the next, five; the third, three; fourth, five; and the last, two; or a total of fifteen seeds—that is, an average of three seeds per capsule. The results were even smaller for the *D. Tatula* capsules, as one had only several half-grown seeds and the other one plump seed and a few imperfect ones. The seeds in normal capsules of the two species average near six hundred.

The Daturas are readily close-fertilized, as shown elsewhere under exclusion experiments, and, in making a cross, the flower needs to be worked some days before the long corolla unfolds.

EXCLUSION EXPERIMENT.

As the work of breeding has been pursued, the desire for further information concerning the self-fertility of flowers of various truck crops has grown, and during the present season

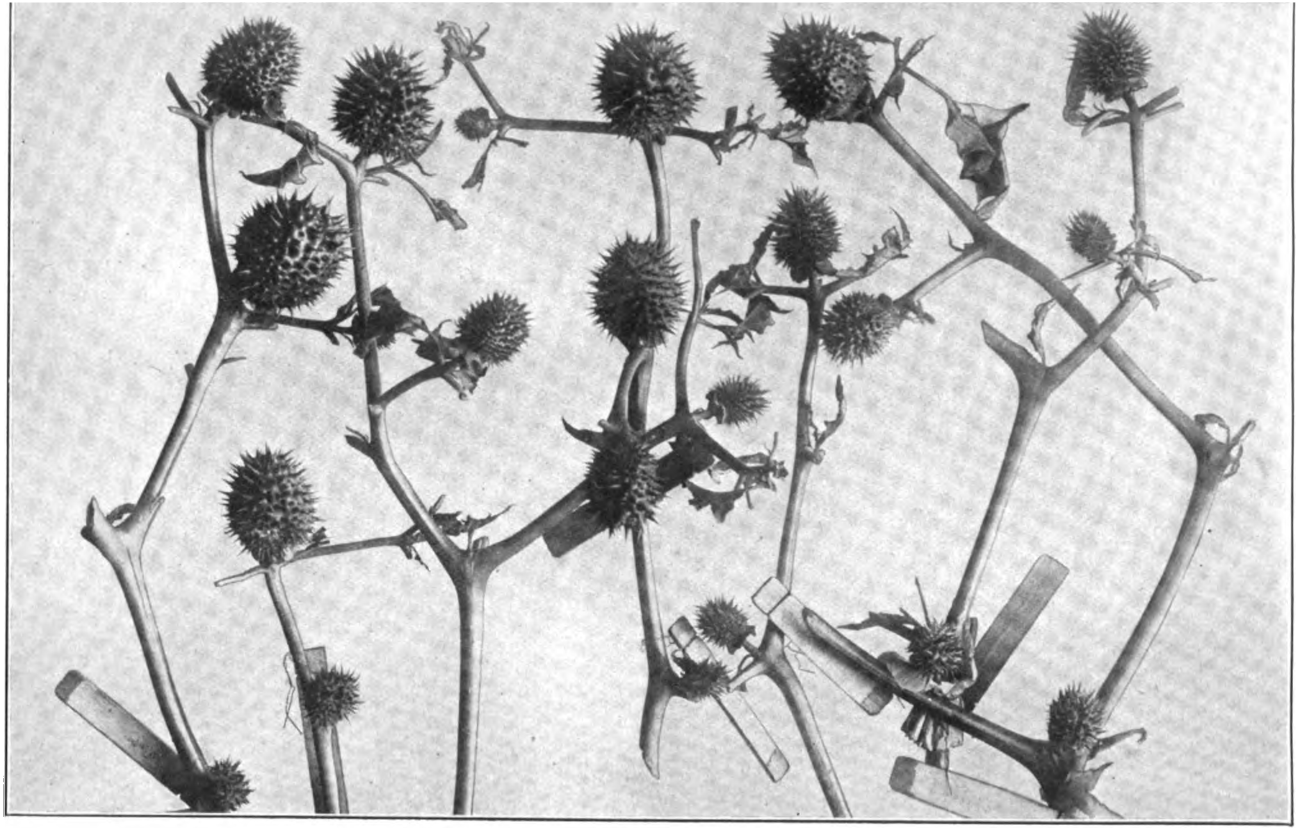


PLATE XXIV. *Datura Capsules.* The small capsules with labels are nearly seedless and result from the preliminary steps in hybridization.

the opportunity was taken for a study of this subject. The method adopted is the simplest, consisting of the isolation of flower buds from all their fellows by means of paper bags and making a record of the results. For ease of computation and to insure a working basis for any possible conclusion, the number of instances in each case was limited to not less than one hundred in eggplants, tomatoes and morning glories, and fifty in daturas.

The preliminary work of exclusion is not particularly tedious, but needs to be done with much care, or else in many instances a second bud, still quite small, may be overlooked and the instance be not above suspicion. In tomatoes, for example, two or three buds may bloom so nearly simultaneously that only the most careful work at this point in the test is effective. The check upon accuracy that is found in the presence of two fruits forming when only one is intended and thus nullifying the particular instance, should not be relied upon, for all flowers in a cluster do not necessarily produce fruits.

The test is easy with eggplants, as here the flowers are large, but few in a cluster and simultaneous blooming not the rule among flowers of the same inflorescence. Morning glory flowers are so large and the buds so conveniently placed as to render the experiment easy at the start.

Eggplant Exclusion Experiment.

From the one hundred flowers employed for the exclusion experiment, ten fruits resulted, varying from three to six inches in length. Five of these, and averaging equally large with the other five, were seedless. The seeds of the latter were not counted but they were not one-tenth as numerous as in those following normally situated flowers.

This test of very limited extent suggests that eggplant blooms are not, as a rule, close-fertilized, and also that fruits of marketable size may be produced that contain no mature seeds, a fact that is not new, but one that has its bearing upon the subject of seedless vegetable fruits.

The small percentage of fruits resulting in this test is probably due to the fact that it was not made until late in the season, when flowers outside of the bags did not generally set fruits. The test will be continued and in season for best results with the hope of learning the effect of such close-breeding upon the offspring of crosses as to the fixation of qualities and also, among commercial varieties, as a test of its weakening tendency.

Tomato Exclusion Experiment.

In order to insure self-fertilization only one bud, before it opened, was allowed to remain on a flower stalk, which was covered with a paper bag to exclude foreign pollen. One hundred buds of nearly the same age were thus covered until the time for fertilization had passed.

In order to compare the number of seeds in the fruits from the self-fertilized with those grown in the open, an adequate number of the latter were harvested from the same plant with the former, and the results are shown in the table below:

Type of Fruit.	Self-Fertilized. No. of Cells.	Self-Fertilized. No. of Seeds.	Fertilized in the open. No. of Cells.	Fertilized in the open. No. of Seeds.
"Cherry,"	3	45	2	59
	2	28	2	50
	2	37	2	50
	2	49	2	64
	2	58	3	65
	2	46	.	...
	3	33	.	...
	2	24	.	...
	2	12	.	...
"Plum" (Small),	2	109	2	124
	2	105	2	117
"Plum" (Medium),	3	78	2	108
	2	89	2	120
	2	48	2	102
	2	31	.	...
"Plum" (Medium),	2	83	2	140
	2	60	2	89
	2	105	2	92
	2	76	.	...
	2	91	.	...
	2	66	.	...
"Plum" (Cross),	4	66	4	203
	4	98	4	225
"Pear" (Medium),	2	105	2	90
	2	77	2	101

Type of Fruit.	Self-Fertilized. No. of Cells.	Self-Fertilized. No. of Seeds.	Fertilized in the open. No. of Cells.	Fertilized in the open. No. of Seeds.
"Pear" (Long), ...	2	69	2	65
	2	45	2	91
	2	64	2	79
	2	64	2	66
	2	96	.	...
"Pear" (Large), ...	2	80	2	117
	2	92	2	84
	2	67	2	87
	2	31	.	...
Long, oval, medium, ...	2	84	2	77
	2	57	2	80
	2	66	2	60
	2	81	2	79
	2	72	.	...
	2	59	.	...
Long. oval, medium, ...	2	58	2	152
	2	95	2	145
	3	105	.	...
	3	97	.	...
	2	97	.	...
Average of 45 fruits, ...		69	Average 30 fruits,	99

Forty-five per cent, of the flowers covered with bags produced fruits and these are upon ten different crosses, all of the small-fruited sorts. The three crosses that gave no self-fertilized fruits have many cells to a fruit, and this suggests that the fewer-celled fruits are more readily self-fertilized, or in other words, the nearer the fruits are to the wild state the more readily they are self-fertilized. The table also shows that, as a rule, the self-fertilized fruits produce less seeds than the cross-fertilized fruits. Within the cross the size of each fruit showed no correlation with the number of seeds or between the number of seeds and the number of cells.

Datura Exclusion Experiment.

Fifty flower buds of the various daturas were covered with bags, but from these only fifteen capsules were found at the end of the season, and the following table gives the seeds that these bore, and, in the second column, are the results of the counting of the seeds in an adequate number of similar capsules that were not bagged:

Species.	Covered Flowers.	Uncovered Flowers.
D. Stramonium,	395	300
	770	820
	925	875
		1,040
		890
D. Tatula,	830	815
	1,005	915
D. Meteloides,	505	440
	505	520
	520	575
	310	285
	400	330
	530	515
D. Tatula/D. Stramonium,	450	455
	530	505
D. Stramonium/D. Tatula,	675	585
D. Meteloides/D. Stramonium,	395	300
Average,	583	598

It is seen that the seeds formed in the capsules of covered flowers is practically the same as in those for uncovered flowers. It is further noted that the *D. Stramonium* and *D. Tatula* have the same seeding capacity, and that this is nearly double that of the *D. Meteloides.*

Morning-Glory Exclusion Experiment.

Seventy-five capsules resulted from the one hundred exclusion tests among the various kinds of morning glories; some of these were immature and a few were used for greenhouse planting, so that only thirty-four were counted, and these produced 152 seeds, or an average of 4.47 seeds for each capsule. An equal number of capsules grown in the open gave 167 seeds, or 4.91 per capsule, a result that indicates that the morning glories are very thoroughly close-fertilizable.

EXPERIMENTS WITH ORNAMENTAL PLANTS.

Antirrhinum (Snap-Dragon). A blend secured between the "Dwarf White" and the "Giant Crimson" was grown this season, together with the parents. In height they approached the "Giant Crimson," bearing many flower spikes of a lighter red than the

PLATE XXV. *Marigold Crosses.* The male and female parents are shown at 1 and 2, respectively, and the cross at 3.

parent, and continuing in bloom the entire season—more profuse bloomers than either parent. Plants of the first generation are now growing at the greenhouse.

Dolichos. One "Suspect" of last year, "Dwarf White/Purple Soudan," has proved to be a true cross. The blend plant was very similar to "Purple Soudan" in climbing habit, purple stem, flower and pod. But three plants were grown of the first generation. Plant 1 was a thrifty, medium climber with foliage, flower and pods resembling the "Dwarf White." Plant 2 showed a stronger climbing tendency, and in foliage and flowers resembled the light purple type of the "Giant Crimson," the pods, however, were white. Plant 3, a climber with purple stem and foliage, failed to reach the blooming period before frost.

Hibiscus. Plants from the suspects Okra-Hibiscus differed in no way from the mother parent. Further attempts have been made to effect this cross, without results.

Ipomeas. Experiments with these interesting climbers have been continued, thirty varieties being grown this season in hills having poles for their support. The attempts at crossing were three hundred and ten, and the number of capsules secured, fifty. It is very difficult to get positive results between species.

The Marigold Cross.

At the greenhouse last winter a cross was secured between the "African" (standard) and the "Dwarf French Marigold." The "Dwarf French" is low growing, compact and spreading, with a dark green foliage of a small type, shown at 1, Plate XXV. It comes more quickly into bloom and produces an abundance of variegated flowers, the principal colors being yellow, orange, burnt orange, and very dark brown, appearing black. In size it is about half as large as the "African" variety, a standard sort of open growth bearing light green leaves, shown at 2.

The blend is a plant (3) resembling the "Dwarf French" in type of foliage and early bloom, but the flower approaches the "African" in size and is orange in color. Blend plants grown in the open began blooming early in the season and were in full flower up to the time of frost. One result of this cross may be a type free from the peculiar odor so disagreeable to many.

The "Pansy-Violet" Hybrid.

Last season a cross was secured between a dark-colored Pansy (1, Plate XXVI.), and the yellow "Violet" (4). The latter has been growing at the Gardens for several years without care, and looks very much like a miniature pansy, having a finer, more narrow-leaved foliage and small yellow flowers, blooming early in the spring.

The blend plants, shown at 2, grown at the greenhouse from the seed started in the fall of 1906, began blooming in March, the flowers having the color of the "violet" but being much larger.

Two of these plants, transferred to the open, bloomed throughout the season until late autumn.

Plants of the first generation from seed sown in July began blooming in September, showing a variation in foliage and shape of flower, but the yellow color still dominated. Two plants produced blooms with purple blotches upon the two large petals and have been marked with the hope of fixing the type. A very hardy, free-blooming pansy is promised by this union, as shown at 3, in the plate.

Field Daisy-Pyrethrum Hybrid.

In 1905, "Suspect" seeds were obtained as a result of breeding together the Pyrethrum and common Daisy, plants from which did not bloom last year, but resembled closely the mother parent. At the blooming period this season the flowers were found to vary in color from the dark red or crimson of the pyrethrum to the white of the daisy. In size some approached the large field daisy, others being smaller with narrower petals, while others bore drooping petals. Seed from the various types has been saved for a study of the first generation plants.

Petunia Crosses.

Several crosses were secured as the result of last year's work, as follows:

Plate XXVI. *Pansy Hybrids.* The Pansy, as the male, and the Field Violet, female, are shown at 1 and 4, respectively, and the blend plants at 2, and some of the types of the next generation at 3.

"Dwarf Star-Giant Crimson." The blend plants were of rampant growth with foliage a medium between the parents and gave blooms with different shades of crimson, but none were marked with "stars."

"Dwarf Star-Standard White." These were tall growing plants in the blend with lighter shades of the "Star" ground color in the flowers, some blooms showing stripes, others white borders, but no pure white flowers.

"Dwarf Star-Single Fringed." This was an interesting lot of plants, many producing large blooms with broad stripes but none having a fringe.

"Single Fringed-Giant Crimson." These were large thrifty plants with good-sized flowers, mostly of a solid color, lighter than the mother parent. A few plants gave the fringed flower with broad-leaved foliage, pointing to a "Crimson Fringed" variety.

Breeding Among Phlox.

Two or three seeds were secured last year as the result of pollinating the "Red Phlox Drummondii" with the "Perennial Blue," a low-growing variety with a profusion of early blooms. But one plant resulted, which did not resemble closely either parent, being of open growth and producing purplish flowers which in color showed a union of the two parents. This hybrid plant was carefully hand-worked, but failed to set any seed. During the summer it stopped blooming and died down, but it is not certain that the perennial tendency will dominate.

A STUDY OF VARIATION IN PLANTS.

Upon the subject of crop improvement, the variation among plants of the same kind, whether that be species or variety, has an important bearing. This fact has led to the consideration of the range of variation that exists in two of the wayside plants that, in the vicinity of the Breeding Grounds as elsewhere, are perhaps all too common. The "Mayweed" or "Feted Camomile" *(Anthemis Cotula L.)* has served to interest the writer as he

walked to and from the grounds to his house, and, one day in October, an hour was taken for the gathering of a set of the heads of this strong-scented weed. A photograph was taken of the collection (Plate XXVII.), the heads being laid down as they were gathered, and, therefore, without any order and no attempts were made to exclude duplicates. In general, the heads are placed with the flowers uppermost as they stand in nature, but a few exceptions to this are made to show the appearance of the involucre as seen looking from below. By glancing along the six somewhat irregular rows, it is seen that some heads are much larger than others, which might be due, in some part, to the age of the flowers and the size of the plant but even in this it was noted in the occasional study of the subject that small heads may be borne by large plants in rich ground while large heads, but few in number, are sometimes produced by small plants that were growing in the hard and poor soil of the roadside. In other words, while unfavorable conditions may dwarf every part of the plant there is, nevertheless, a wide range of variation in the number of the individual flowers and the size of the head of blossoms among plants that are seemingly similarly situated.

Perhaps the part that shows at once the greatest range of variation is in the conspicuous ray flowers. They are more frequently thirteen than any other number, a fact that has been dwelt upon by Professor De Vries in connection with other members of the sunflower family of plants; but in number they vary far less than in their size and shape. It is seen that some are quite short and broad, and need to lap each other at the base, while other heads have the rays long and narrow, with a space between them at the base of nearly their own width; others are flat and deeply notched at the free end, and some are inclined to be "quill" shaped; in fact, a head was found in which the rays were truly tubular, but this is not in the Plate.

In a similar cursory way a study was made of the "wild carrot" *(Daucus Carota L.)*, and samples of the umbels placed in press. This species is very variable in many of its parts, and perhaps no more so in the inflorescence than elsewhere, but it admits more readily of a photographic record. The individual flowers are so small that but little attention was paid to them,

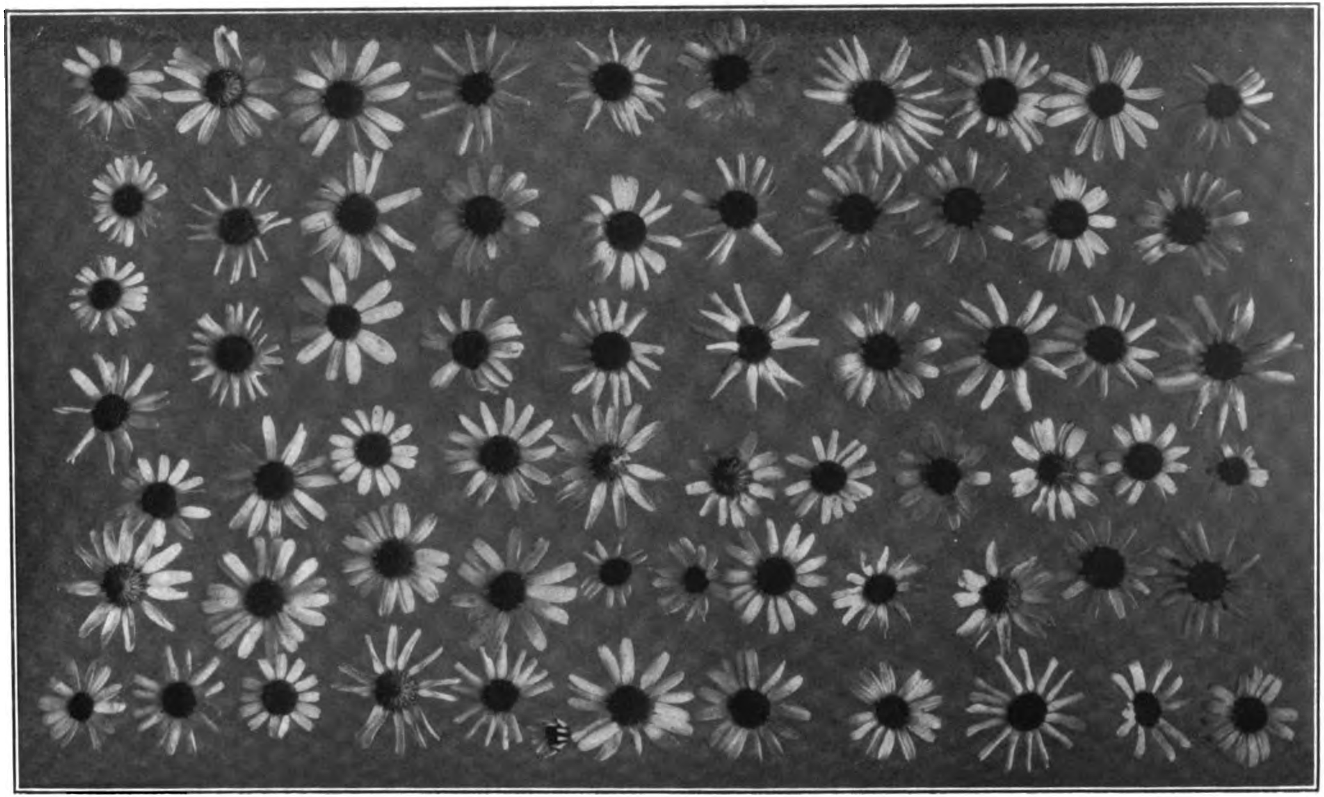


PLATE XXVII. *Common Mayweed, or Feted Camomile.* Sixty-five heads, gathered by the wayside, illustrating nearly as many forms.

but their variations in size and shape probably affect greatly the appearance of the umbels. In the first place, there is much difference observed in the color, it ranging from the ordinary white to a decided pink. As known to all observers of the carrot plant, there are pink neutral blossoms usually in the center of the inflorescence, and the stems and leaves in some specimens, especially in autumn, show this coloration to a considerable extent. It is also a matter of common observation that the young flower clusters are often of an inviting pink before the blossoms unfold, all of which has led to the saving of seed from the plants that show the pink color quite generally throughout the plant in the hope of developing a variety that may be acceptable as an ornamental plant.

The length of the stems bearing the secondary clusters varies greatly, thus making some inflorescence, open or "loose," while others are quite closed or "dense." Again, the main flower stems are sometimes so uniformly unequal as to make the whole top a hemisphere, while others are flat, and, furthermore, the secondary stems may in like manner bring the flowers to a level with each other, to form the opposite extreme in thimble-shaped clusters. The clusters of any one plant are constant.

If bred within the plant it is likely that a large number of types might be secured that would soon become fixed.

DISEASES OF PLANTS UPON HOME GROUNDS AND ELSEWHERE.

Upon the Breeding Grounds there has been comparative exemption from serious fungous diseases. The two blocks of early sweet corn, namely, "Malamo" and "Malakosby," showed some smut, the more being upon the former variety. There have been similar reports from the testers who have the Station novelties upon trial.

The tomatoes have been free from any serious trouble, the leaf blight being somewhat in evidence, and an examination did not show that any varieties were particularly infested. The so-called "yellow foliage" plants showed the "spots" most upon the leaves, but this may not indicate that they were more diseased.

It is natural, however, to suspect that the less green foliage might be more susceptible, as is true with some of the ornamental plants with variegated foliage. Leaving the tomato fruits upon the vines after ripening, as is done for purposes of study, tends to develop fruit fungi, but, as a rule, this has been surprisingly limited in amount. Lifting up the vines with metal supports, or tying them to stakes, is an advantage.

Beans the present season have not suffered materially from pod-spot, and the mildew of the limas was not troublesome. Spraying for the prevention of the latter disease has been in vogue under the general rule that delays are unwise in dealing with such enemies. Last year the crop was materially damaged throughout the state by the mildew.

Squashes have not been troubled seriously with any fungous enemies, but various insect pests have caused much damage, especially the grub in the vine varieties. Bottle gourds were much infested with an anthracnose.

Peas, for the early varieties, escaped from any disease, but the later ones became mildewed before maturing, the plants being grown for seed and not table supply. A late crop of various crosses was planted in August, after sweet corn, and the mildew was kept in check with weekly sprayings of the Bordeaux mixture.

Last year the Udo blighted so badly that only the least-affected plants were removed to a new place and the old bed was destroyed. The plants the present season, shortly after yielding a fair quantity of stems, began to show blight, and some of them failed to make much growth; the others attained four feet in height, but showed the blight in leaf and stem. Spraying was purposely omitted, but it is possible that, with occasional treatment, the plants might have been thrifty.

Among the plants in the ornamental and trial grounds the *Solanum Commersonii*, beginning in September, showed a large amount of the Late Blight (*Phytophthora infestans*) in all parts of the foliage and stems. A number of trial hills of U. S. D. A. novelties of the ordinary potatoes, growing a short distance from the above relative, showed no signs of the disease.

Asparagus Rust.

Perhaps the most destructive fungous enemy to any truck crop in recent years is the rust of the asparagus, but for the past two seasons it has been less in evidence, in part due to the introduction of more resistant varieties. Recently letters of inquiry have been sent to the leading growers of this vegetable, and from their replies it seems clear that the present season has seen a further advance toward healthful asparagus fields. One report contains the following statement: "The asparagus here is in fine condition, but little rust; in fact, some fields almost totally exempt." Another writes that: "The asparagus fields in this vicinity, although affected with rust, are not so much so as in former years, some fields that rusted last year quite badly a few weeks ago could not be detected with rust by close examination." The following report is assuring: "There is very little asparagus rust on well-cared-for and up-to-date fields, and especially is this true on those varieties grown from seed taken from plants which showed the greatest rust-resisting qualities. Until the heavy frosts a week ago my six-year-old beds were as green as the middle of July. Asparagus never looked better in this vicinity." Additional facts are given in another report as follows: "While there may be traces of rust, I have noticed none, and do not think it of sufficient importance on any beds here to cause damage, if any at all. This alludes to Palmetto. Where the old varieties are still in existence, there you see rust; even there it is not so bad as formerly."

Forest Fungi.

Two diseases among forest trees have been unusually abundant the present season. Early in the summer many complaints were made of a trouble with the foliage of the "Plane-tree," "Button-ball," or "Sycamore" (*Platanus occidentalis*). This was due to a fungus (*Gloeosporium nervisequium*) that preys upon the young shoots, often destroying them and the partially-developed leaves they bear. Early in June, in a ride from Trenton to Belvi-

dere, it was observed that nearly every plane-tree was so badly affected as to suggest that a hard frost had visited the region. This contagious fungous disease is so prevalent as to discourage the use of this tree for any sort of planting, and, while it might be held in check by spraying, the trouble of spraying is too great to warrant the use of fungicides.

The second forest tree disease, much complained of, is a stem blight of the Chestnut, due to *Diaporthe parasitica,* recently studied by Professor W. A. Murrill, who affirms that it enters the stem, often through wounds, and spreading beneath the outer bark may girdle the tree. The infested parts bear many pimples where the spores are produced in large numbers. As the fungus works so out of reach of remedies it is recommended to remove all badly-infested trees and refrain from planting young chestnuts in localities where the disease is troublesome.

General Notes.

Among orchard troubles the pear twig blight, peach curl and apple fruit rot have been somewhat in evidence. In the fruit garden complaints have been made of the rust of the blackberry, anthracnose of raspberry, blight of strawberry and, among truck crops, the potatoes (both white and sweet) have had their rots and blights. Tomato growers in parts of the State have suffered from a leaf disease, and the cranberry growers, while still having their crop shortened by "scald" and "rot," are learning to spray against them with good results.

Rainfall of the Growing Season for Past Nineteen Years.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	Average.
April,	5.32	2.65	2.19	2.49	5.21	3.09	4.88	1.35	3.79	3.74	1.73	2.29	6.31	3.62	3.97	3.43	2.88	3.64	3.78	3.49
May,	4.09	4.24	2.97	5.04	4.07	7.72	2.85	3.21	5.68	7.00	1.92	4.71	5.60	2.04	0.59	2.60	1.71	4.21	5.05	3.96
June,	3.73	3.59	2.92	3.85	2.95	2.28	3.24	5.46	3.38	2.10	2.50	3.08	1.57	6.57	7.68	3.13	3.43	4.48	4.41	3.70
July,	10.19	5.62	5.30	4.03	2.72	1.66	4.26	5.50	11.42	4.96	5.75	4.74	5.87	4.78	5.51	4.87	4.06	5.58	2.62	5.23
August,	5.18	4.90	5.32	3.63	6.52	2.58	1.83	4.39	5.36	4.36	2.68	9.43	3.91	6.95	6.95	6.62	5.72	5.95	3.45	5.04
September,	8.36	4.75	2.46	1.81	3.30	7.46	1.07	4.37	1.65	2.00	5.88	2.86	3.38	5.65	3.34	4.79	5.23	2.19	8.08	4.14
Totals,	36.87	25.75	21.16	20.85	24.77	24.79	18.13	24.28	31.28	24.16	20.46	27.11	26.64	29.61	28.04	25.44	23.03	26.05	27.39	25.56
Average,	6.14	4.29	3.53	3.47	4.13	4.13	3.02	4.05	5.21	4.03	3.41	4.52	4.44	4.93	4.67	4.24	3.84	4.34	4.56	4.26
Rank in Wetness,	1	9	16	17	12	11	19	13	2	14	18	6	7	3	4	10	15	8	5	
Rank in Dryness,	19	11	4	3	8	9	1	7	18	6	2	14	13	17	16	10	5	12	15	

Temperature of the Growing Season for Past Nineteen Years.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	Average.
April,	51.2	50.4	52.0	49.3	49.2	50.3	49.1	52.4	50.4	47.8	49.9	50.8	48.3	50.2	50.9	46.7	49.9	51.2	45.2	49.7
May,	62.3	60.7	59.5	60.1	59.4	61.4	60.9	65.3	60.6	58.5	61.1	60.9	58.6	60.3	62.7	62.8	61.4	61.0	55.4	60.7
June,	69.9	70.7	69.7	72.4	69.7	70.6	71.7	68.1	66.1	70.1	72.3	70.4	70.0	67.5	64.0	68.6	68.3	70.4	64.7	69.2
July,	73.4	72.5	70.1	74.3	73.9	75.7	70.9	75.0	74.1	75.3	74.7	75.9	77.3	73.0	73.3	72.3	74.4	72.8	73.6	73.8
August,	69.6	71.5	72.8	73.4	72.8	70.9	74.2	73.6	71.0	74.8	72.3	76.3	73.8	70.1	68.4	70.8	71.1	74.6	70.5	72.2
September,	64.8	64.4	68.7	64.2	62.7	68.3	69.7	65.1	65.5	68.6	64.4	69.9	66.8	64.6	65.0	64.8	65.4	68.9	67.1	66.3
Average,	65.2	65.0	65.4	65.6	64.6	66.2	66.1	66.6	64.6	65.9	65.8	67.4	65.8	64.3	64.0	64.3	65.1	66.5	62.7	65.3
Rank in Warmth,	12	13	10	9	14	4	5	2	15	6	7	1	8	16	18	17	11	3	19	
Rank in Coldness,	8	7	10	11	6	16	15	18	5	14	13	19	12	4	2	3	9	17	1	

Sunshine of the Growing Season for the Past Nineteen Years in Percentage of Clear-Partly-Cloudy Days.

	1889. Per cent.	1890. Per cent.	1891. Per cent.	1892. Per cent.	1893. Per cent.	1894. Per cent.	1895. Per cent.	1896. Per cent.	1897. Per cent.	1898. Per cent.	1899. Per cent.	1900. Per cent.	1901. Per cent.	1902. Per cent.	1903. Per cent.	1904. Per cent.	1905. Per cent.	1906. Per cent.	1907. Per cent.	Average. Per cent.
April, ...	53	76	80	53	60	70	60	76	83	62	87	77	50	70	66	70	77	83	67	69.0
May, ...	65	66	64	71	69	65	78	71	78	52	77	75	58	84	84	84	74	77	68	67.0
June, ...	66	80	76	76	70	83	73	73	80	87	84	80	87	83	53	77	77	73	73	76.0
July, ...	58	76	69	84	87	84	78	74	68	74	77	87	71	71	84	74	81	81	64	75.1
August, ...	74	77	61	78	81	80	90	87	84	77	71	84	71	90	65	81	74	68	84	77.1
September, ...	53	66	83	87	73	66	90	70	87	83	80	80	80	60	83	80	76	80	60	75.1
Average, ...	61.5	73.5	72.2	74.8	73.3	74.7	78.2	75.2	80.0	72.5	79.3	80.5	69.5	76.3	72.5	77.7	76.5	77.0	69.3	73.2
Rank in Brightness, .	19	12	16	10	13	11	4	9	2	14	3	1	17	8	15	5	7	6	18	
Rank in Darkness, ..	1	8	4	10	7	9	16	11	18	6	17	19	3	12	5	15	13	14	2	

WEATHER NOTES OF THE GROWING SEASON.

Upon page 383 is given a table of the rainfall for New Jersey for the growing season, April to September inclusive, for the past nineteen years. From this table, made up from the monthly reports of the New Jersey Section of the United States Weather Bureau, and, therfore, based upon a large number of records made in all counties of the State, it is seen that for the current year the precipitation has been somewhat above (.30) the average. The first half of the season was wet—May unusually so—followed by a very dry July and August, which, in turn, were succeeded by a wet September, in which the amount of rainfall was nearly double the normal. While the season was not far from the average in total rain, this was so unequally distributed as to be quite unfavorable for the growing of crops.

The temperature table upon page 384 shows that the last was the coldest growing season within the past nineteen years, and, so far as this relates to crop-growing, little can be said in its favor.

Upon page 385 is a record of the sunshine, and it may be observed that its record for dark weather is only exceeded by the year 1889 at the beginning of the present series.

As a whole, the growing season for 1907 was very cold and cloudy, two meterological factors that are naturally correlated, and the rainfall was excessive for May, June and September, while the midsummer was dry and not conducive to good crops because of lack of sunshine and warmth.

REPORT OF THE ENTOMOLOGIST.

Report of the Entomologist.

BY JOHN B. SMITH, SC. D.

GENERAL REVIEW.

The conditions of temperature and precipitation varied considerably in different parts of the State. In a general way it was dry, or even very dry north of the red shale line, until well along in July. In the southern areas there were showers in plenty; but irregularly distributed, so that there might be a flood in one locality, while another in great need of moisture received nothing. After midsummer there was an abundance of rain throughout the State. Spring came in slowly and with many late frosts after a period of early warmth. Frosts began early and followed each other in rapid succession from early October.

The results upon insect development were interesting. Everything was late in starting, and for a time decidedly irregular; but as the season advanced, those insects that normally came late arrived on time, and found as companions a series of species which in other seasons were well out of the way. There was no startling outbreak of any kind, and quite a number of the species that are usually troublesome were conspicuous by their absence, or greatly reduced numbers. Scale insects, as a whole, did not do well; potato beetles were very late in making their appearance and did much less injury than usual; cut-worms did much less injury than usual, and root-maggots were not nearly so abundant as in 1906. On the other hand, different species became much more abundant than for some years past. The bag-worm on shade trees and hedges; the fall web worm on orchard and road trees; plant lice of various kinds on field and orchard

crops; the corn-worm, and a variety more made up very fairly for the deficiency of the rarer species.

In the general work of the office a large number of questions were answered, specific advice was given and minor investigations were made that do not show for much, yet take a great deal of time and are of direct benefit. The experiments with root-maggots were continued to complete our knowledge of the habits of the insects under varying conditions and to test certain of the insecticides more fully under field conditions. So, also experiments with and tests of insecticides have been continued, and some interesting results were secured. It has proved possible, this season, by co-operating with the inspection work of the State Entomologist, for Mr. Dickerson and myself to verify the claims made for crude carbolic acid as a scale destroyer, and also to observe more closely than ever before the results of ordinary orchard spraying operations. In a number of cases applications were made at my suggestion, and in part with material supplied by the Station.

Two bulletins were issued during the year: No. 200, embodying the results of work done on the root-maggots in 1906, in such shape as to be available during the season of 1907, and No. 203 on "Some Household Pests," embodying the results of our observations, collections and correspondence during the past twenty years—nineteen of them in this Station. There has been no change in the staff of the office.

The meetings of the Association of Economic Entomologists were held during the winter of 1906-'07, in New York City, and were attended by all the members of the staff. The meetings of the Entomological Society of America in connection with the International Congress of Zoologists were held in Boston during mid-summer, and were attended by the Entomologist. The meetings of the various entomological societies in New York, Brooklyn, Newark and Philadelphia, were attended whenever possible. to keep in touch with all branches of the science and with all the advances and new knowledge communicated at such meetings.

Assistance has been given in other directions than those already mentioned, whenever asked for. A series of boxes was overhauled, and some were newly prepared for the exhibition made

by the New Jersey State Museum at Jamestown. A series of cases illustrating shade tree insects was prepared for the Forestry Exhibition at the Free Library in the city of Newark. A series of cases is in hand for the Newark Shade Tree Commission, and in all ways we have tried to co-operate with bodies and boards working toward the advancement of agriculture and arboriculture. To this end also, lectures have been given at meetings of farmers, fruit growers, improvement societies and other local bodies.

Our general collection is steadily increasing in extent and value, and much of it has been arranged and determined during the year. There is a large amount of material that is simply stored until opportunity is afforded to make it available in some way; either as part of the State Museum at Trenton or as a part of an Agricultural Museum, which is fast becoming a necessity as part of the outfit of the Station and of the courses in agriculture.

Mr. John A. Grossbeck has again assisted materially in the general work of the office and had general charge of the illustration and collection department of the office.

The correspondence of the office during the fiscal year extending from November 1st, 1906, to October 31st, 1907, covers 3,000 pages of letter book and represents about 4,000 individual communications.

ORCHARD INSECTS.

Orchards have, on the whole, suffered less from insect attack than in other recent years. All the usual pests were present to a greater or less extent and exacted toll; but there was less feeding on the leaves than usual, borers were not conspicuous and even the plum curculio seemed to be less troublesome than usual. There seemed materially less leaf hopper, especially on apple trees, and except in a few localities, plant lice were not conspicuous. But while conditions were good in general, there were some exceptions and especially in those that directly influence the crop while not causing injury to the tree itself.

Codling Moths.

Apple-worms, the larvæ of the codling moths, were far more than usually abundant during the past season, and caused a much greater money loss than fruit growers generally realize. There were a great many apples in New Jersey, taken altogether, and a great many of them were on trees in orchards where not much attention is paid to spraying, though they may be otherwise pretty well cared for. On such orchards this year more than 60 per cent. of the apples that remained on the trees until harvest were wormy, and at least half as many more dropped prematurely. No wormy apple is ever first grade, no matter what it may be in size, form and color, and with the prices as they ranged this fall, every apple was a distinctly valuable item.

In one large orchard of old trees not 20 per cent. of the fruit brought top prices, and there were few between first and culls. The owner had cull apples enough to get over two thousand dollars had they ranged as did his firsts, and the expenditure of less than 10 per cent. of that amount in spraying work would have secured him that sum.

Control of the codling moth in most parts of New Jersey is so easy and so certain that it speaks ill for the progressiveness of the fruit growers to find that they consent to lose anywhere from 40 to 60 per cent. of crop value rather than go to the trouble of spraying two or three times with Paris green or other arsenite.

Those in our State who are fruit growers primarily are strictly up to date in this matter, but there are many farmers, especially in the northern parts, who have from 100 to 300 trees, or sometimes only 50, which are allowed to care for themselves so far as insects are concerned, and these lower the percentage of our strictly first-class fruit.

Black Peach Aphis.

This species has been more than usually troublesome during the summer. Before the end of May complaints of trouble came from Cumberland county and the trouble extended to Hunterdon

county before the end of the season. Very little was seen of the leaf-form of the insect; the root-form was most destructive. Nevertheless, the unusual abundance of the specimens on the shoots first attracted attention to the insects and suggested the reason for the poor condition of the trees. Young trees as usual were affected most, and while older ones may have been equally infested they did not show it so much.

In Hunterdon county nursery trees were mainly affected, and quite a number of them were killed—one seedling block was so badly injured that it was plowed out.

This is the first time in several years that this species has been abundant enough to attract attention, and little or nothing was done to check it or prevent injury. In fact its presence was not realized until the injury was actually done in most cases, and then the growers did not know what measures to resort to. Practically, destructive applications are not very effective; but finely ground tobacco does exert a considerable influence for good. Worked into the soil beneath an infested tree it served to kill many of the lice, and as a fertilizer to stimulate the tree; the addition of a mixture of kainit and a little nitrate of soda will help materially by helping the resisting power of the plant life.

Fall Web Worm.

Beginning early in September the nests of the fall web-worm became conspicuous throughout the State, though not to the same extent everywhere. Wild cherry and many other trees along the roadside were defoliated, and in orchards where no spraying was done the trees were often a sight. Large apple trees were in some cases completely stripped, and pear trees were not infrequently altogether enveloped by the silken webs of the caterpillars. The difference between orchards neglected and orchards cared for was sharply brought out by this insect, and the effect of the defoliation will be to hasten the death of many an apple tree making a good fight against the San José scale and slow starvation in sod.

This great increase in fall was not unexpected when I noticed the unusual number of moths of the early brood. The spring

nests were not particularly abundant, but they seem to have matured all their inhabitants, and thus provided for a heavy fall supply. As the insects leave their nests to feed, there is no difficulty in reaching them with arsenical poisons; but they need a heavy dose, especially after they have become well grown.

San José Scale.

This has not been, on the whole, quite so destructive as in the few years last past. The weather conditions early in the season were decidedly against it, and breeding did not begin until July—in Northern New Jersey not until the month was well advanced. And this first brood was not heavy, even on badly infested trees. It seemed as if at the period of the maturing of the males a large percentage of these had been killed off by freezing weather, and many females, in consequence, never reproduced at all. Slow and scanty increase was the rule throughout the summer, and even in August neither larvæ nor young scales were at all abundant. But in September conditions had again become more favorable to the insects, and trees which a month before had appeared to be tolerably free, were swarming with larvæ and speckled with white sets—and it was not until the middle of that month that this heavy brood developed.

There is danger, therefore, that growers, especially of peach trees who found fruit and trees in good condition at harvest time, may not realize the importance of this late increase, and may find badly infested trees next spring where they expected to have them practically clean.

Nevertheless, the late start and slow increase during the summer has been of enormous benefit to the infested trees, and it has undoubtedly prevented spread and badly infested fruit.

It has also, incidentally, enabled a great many insecticide applications to make an unusually good showing early in the year. Up to the end of August the man who bored a hole in his tree and stuffed it with a patent compound was able to claim that his tree looked just as well as the one his neighbor sprayed with oil or lime and sulphur, and quite a number of persons have begun to talk hopefully of the natural disappearance of the scale.

I believe that conditions have improved materially, and that in many cases and under many conditions trees are resisting the scale much better than they have done in the past. But the scale is by no means disappearing, nor is the decrease in numbers the result of any increase in the natural enemies of the species. Plants and insects are slowly becoming adapted to each other; but the process is a slow one, and no grower with an orchard for which he has any regard can afford to wait for it.

A very large number of orchards was visited during the season by Mr. Dickerson and myself, and rather a close study was made of the conditions under which those trees grow that seem to resist the scale best. It has been no uncommon complaint by men who cultivate and spray that their trees suffered more than those of some of their neighbors who did neither, or certainly did not spray. And the complaint was justified to a great extent. There are apple orchards today in districts in which scale occurs everywhere and has occurred for ten years, in which no spraying has ever been done and from which crops have been taken each year. Scale is present in these orchards—plenty of it—and has been present for years; but it seems to do no more than hold its own, and the fruit is saleable. To be sure some of these trees are slowly dying now; but not from scale attack in all cases. In fact, in the case of apple orchards, many old trees are dying without enough scale on the entire tree to kill one branch; but the scale gets the credit for the death.

In a general way the more vigorous and sappy the tree growth, the more it is likely to suffer from scale attack. The bark is thin and jucy, the trees are smooth and nice, and the scale insects thrive as well as the tree until they poison and kill it. Good cultivation, good care and good feeding, especially in apple orchards, favor scale development and furnish a condition under which the horticulturist must fight continually for his orchard.

It is noteworthy that all the orchards that have stood for years without treatment have had little care and less food. The trees have made little growth each year other than fruit spurs, and the bark is hard and tough. Up to the very tips a hard skin is found, and on cutting this skin with a knife, the sap does not lie close to the surface and does not seem to be so abundant. The larval scales

are at a decided disadvantage, and on a great portion of the bark they simply cannot set at all; or if they do, they get mighty little nourishment. Orchards and single trees have stood in this condition for years; but, inevitably, that same combination that makes for resistance to the scale, starves out the tree and it slowly dies—like a number of orchards that I have seen and studied during recent years. Apple trees partly cared for, live longer. They get sufficient nourishment to keep them going, and they are toughened by conditions; and some varieties stand this method of treatment much better than others and become almost scale-proof. In almost every dying old orchard there are some varieties in much better condition than others, and even individual trees stand out against the destructive surroundings. Now these individual trees or varieties are not kept clean by parasites or other enemies that do not occur on the other trees. It is simply a toughening of the surface, and a sap condition that makes it so difficult for the insects to get a hold, that very few succeed in doing it. The same varieties in other conditions, favoring a ranker growth, are often as seriously injured as any others. I have met with no varieties that are uniformly exempt from scale attack.

We are not without examples of plum and peach trees badly infested by scales becoming almost completely freed. In almost all cases—not quite all—this freedom came after the trees had been abandoned and left to take care of themselves. They hardened up and the scale failed to maintaine itself further. By no means all abandoned trees free themselves from scale; most of them die; but enough of them live on to attract attention.

I have noted several times that where peach and plum trees have been de-horned or cut back to stumps, there was little or no scale for one, two or three years thereafter. All that was on the old tough bark simply died out, and left a practically clean tree.

I would not have it understood in any way that I advocate starving or neglecting trees to free them from scale attack. I simply wish to draw attention to the fact that thin-skinned, sappy, rapidly growing trees suffer more from scale attack, and to suggest that if hardiness of growth could be secured, even at the expense of rapidity, it might make control more easy.

As to the work done with the scale, that has been altogether in the direction of testing insectides and noting the effects of the various applications made throughout the state. Records of the insecticides results will be found under the appropriate headings; but in a general way much attention has been paid to indirect treatments, *i. e.*, acting through the circulation like carbolic acid and similar preparations.

Touching on this, and also in a way bearing on the question of hardening trees, the late Judge Woodbridge Strong always claimed that he had no trouble whatever in controlling the scale and that he never sprayed a tree. I have frequently visited his orchard at New Brunswick, and know positively that for ten years at least the scale has been in his trees—mostly pear. I know also that he never lost a tree from scale attack, and that while I could always find more or less of it, I never found any bad infestation. Not until the spring of 1907 did the Judge tell me what he did, and then it appeared that it was simply slaked lime applied early in the spring that was relied upon. The soil was drawn away from the trunk with a hoe to form a shallow dish about two to three feet in diameter, according to the size of the tree, and in this from two to three quarts of slaked lime reduced in a bucket of water was poured; quantity depending on the size of the tree.

The idea was that the tree would take up an excess of lime through the roots when there was plenty of it available, and that this excess of lime would harden the wood and make it unsuitable for scale consumption. The Judge never allowed rank growth on any trees, and many of them were actually dwarfed. They rarely made much growth in any one year, but they always bore heavily and remained free from scale.

Lime is present in considerable quantity in the normal wood growth, but whether it can be added to artificially, and whether, if it can be, this addition will add to the resisting power of the tree, are questions that must be tried out and answered by experiment.

Unfortunately the information came to me so late in the season that it could not be tried so as to secure best results this year. The liming should be done at or just before the tree is starting,

and the later in the season it is done the less certain are the results, so Judge Strong said.

I tried the lime on three trees in the Experiment Orchard—Nos. 18, 19 and 25—selected because they were the scaliest I had and those on which the scale usually bred most abundantly. The application was made May 18, and consisted of about 3 gallons to each tree. Up to the middle of September there was only the merest trace of scale on the trees, and on the 20th of that month only a scant scattring of new scales was to be seen. This was better than these trees had ever done before; but unfortunately every other tree in this series shared the same freedom, and it is absolutely impossible to claim for these trees that their clean condition was due to the application of the lime.

As a further test I put in a series of a dozen infested apple trees; the worst I could find in a condemned nursery block and five of these received, soon after they were set out, 1 quart of slaked lime reduced in half a bucket of water. On September 25th, there was only a slight scattering of new scales on these treated trees and no more on those that had not been treated. In other words, while all the lime-treated trees were in good condition, they were no better than those that had received no treatment.

A series of 12 similar infested apple trees was set out on the College Farm; all of these received lime applications at the rate of 1 quart slaked in one-half pail of water. The results were practically the same. Mr. Dickerson who made the applications and examinations reports under date of September 28, that every tree is more or less infested, and while the infestation is not destructive in any case, there is a very decided increase over last spring and as much as the season would warrant. A more full account of what was done with these trees appears elsewhere in the report.

The matter is of sufficient interest to warrant further experiments under orchard conditions if I can find some trees to serve as suitable subjects.

The observations made on the effects of carbolic acid applied to tree trunks have not demonstrated its effectiveness; but neither has it been proved that it may not under some conditions

be of some use. In another section of this Report that subject is presented at length.

In a general way the lime and sulphur combinations and the soluble oils have been relied upon by orchardists and both have been, on the whole, successful. As usual, there have been failures which it is simply impossible to explain, with both materials. The "Rex" lime and sulphur mixture has been tried in competition with the home-made mixture and with equally good results. Scalecide has been most generally used of the soluble oils, and has been very effective on the whole. Target brand scale destroyer has also been effective; but there has been much complaint that the emulsion was not stable and that when allowed to stand for a time it became unfit for use. A soluble oil prepared by the Thomsen Chemical Company of Baltimore was used to some extent, and with very good results. But as I have already indicated, almost everything made a good showing early in the season.

I have seen no reason to change my conclusion that the control of the scale is no longer a matter of securing an insecticide of sufficient killing power; it is a matter of application merely and mechanical in character. Either lime and sulphur or soluble oils will answer as killing agents, if they are made to reach the insects themselves.

THE EXPERIMENT ORCHARD.

A preliminary inspection was made on March 18th, to determine whether spring applications were needed by any of the trees. Mr. Dickerson made the examination, and from his report I decided to let things go for the season. Some peach borer was noted, and tree 44 was still dead; there was some blight on the Japan Golden Russet pears, and there were some dead twigs on the chestnut. Otherwise matters were not bad. As the bark beetles had obtained a foothold in tree No. 44 I had it cut out and burned April 15th.

May 1st, I resumed the occupancy of my place and began a systematic trimming out and shaping up so far as conditions permitted.

May 18th, trees 18, 19 and 25 received an application of freshly slaked lime around the base. A basin 6–8 inches deep was hoed around each tree, and into each I poured 2 quarts of slaked lime reduced to a bucket holding about 3 gallons.

May 25th, sprayed trees 29, 47 and 48 with the Vreeland arsenate of lead, 2½ pounds in 25 gallons of water. The application was primarily a test of the insecticide as to its action on foliage and was made with a Deming Pump, and an extension gas-pipe rod tipped with a single "Friend" nozzle. This outfit proved so satisfactory that it was used throughout the season. The single Friend nozzle does the work of a doublet or even a triplet Vermorel, and proved the best all-around nozzle that I have ever used. It rained during the night of the 25th, more or less during the 26th, quite heavily during the night of the 26th and very heavily, indeed, on the 27th.

May 28th, picked off all the visible fruit on trees 18 and 19. Fully 90 per cent. of it was infested by the pear midge and I preferred to destroy everything for this year so as to prevent the maturing of the adults. On the 29th made another application of Vreeland arsenate of lead, 2½ pounds to 40 gallons of water on trees 38 and 43, and on the 30th treated tree 29 in the same way, partly duplicating also the application on tree 38.

May 30th, also, I made up a combination of a 6 lb. bag of "Target brand quick Bordeaux" and 2 pounds of "Disparene" in 40 gallons of water and applied to trees 1, 2, 3, 8, 43 and 48. Tree 47 received a partial dose when spraying 48, and tree 42 got an incidental dose of arsenate of lead while spraying 38. Then reduced the remaining mixture to half strength, and sprayed trees 18, 19, 23, 24 and 33. During the night of the 1st a heavy storm began and continued throughout June 2d, and when that was over there was very little appearance of spray remaining.

June 12th, prepared another 40-gallon tank of the "Target brand quick Bordeaux" with 2 pounds of Target brand arsenate of lead, and sprayed trees 1, 2, 3, 8, 19, 20, 29, 30, 33, 38 and 48.

July 23d, another lot of the same combination was prepared, using the Vreeland arsenate of lead and sprayed all the grapes and the large apple trees—2, 8, 29, 30 and 38. This application stuck

for the balance of the season and no more general sprayings were made.

The trees, as a whole, remained remarkably free from scale throughout the year. The last applications of an insecticide as against the scale were made in the late fall of 1905, and these cleaned the trees very well. They seem now to have reached the stage where the scale has little or no further effect on them. There is probably not a tree on which there are not some specimens; but they certainly have not increased and multiplied according to their opportunities. The season of 1907 was not a good one for the scale; but even this season it multiplied in late summer, while 1906 was certainly not a bad one for it. Even the most susceptible of the trees, those that have always been infested and have required continued and persistent treatment to prevent injury, have now stood two full seasons without harm and are not scaly enough to induce me to use anything during the current winter.

Tree 1—Mariana Plum. Was in full bloom—a mass of white flowers—on May 3d. As no pruning at all was done in 1906, it is now a tangled mass of interlacing and interfering twigs. May 25th the tree was out of bloom and had made a very heavy set of fruit, out of which not twenty examples matured, eventually.

May 30th, sprayed with the "Target brand Bordeaux" and "Disparene," covering thoroughly. June 12th, duplicated the application, Target brand arsenate of lead replacing the "Disparene." This spraying remained visible until well along in July. In early August a good many leaves turned yellow and dropped, and shot-hole fungus became noticeable. On the 18th the few ripe fruits were gathered, all free from scale. There was little change afterward. The foliage remained somewhat ragged; but no more of it fell, and on October 30th, after a series of heavy frosts, the tree was yet full of green leaves, while the new wood was clean, smooth and free from scale.

Tree 2—Yellow Transparent Apple. The tree started in good shape, a moderate bloom showing in early May and disappearing about the 20th, leaving a small set of fruit. May 3d, a scattering scale infestation was noted on the newer wood; but no live examples were found on the old wood.

May 20th, sprayed with the Bordeaux mixture and "Disparene," and on June 12th this application was duplicated; the "Target brand" arsenate of lead replacing the "Disparene." This application stuck until early July, and on the 23d of that month was again duplicated; Vreeland arsenate of lead serving as the insecticide in this instance. The fruit developed slowly and some of the apples turned rusty on one side and began to crack in July. By August 18th, all the fruit had been removed, about 2 baskets in all, and there was not a scale on any specimen. There was at that time a great deal of yellow foliage and some of that was dropping; otherwise the tree was in good condition and there was much less leaf-hopper injury than usual.

September 22d, quite a bit of the foliage had dropped and the work of the leaf-hopper was more obvious. The loss of foliage has been toward the outside of the tree and the centre looks much better. Some of the shoots had 2 or 3 leaves at base, then a blank space and finally a little tuft at tip. Moving larvæ and recent sets were then visible on most of the older shoots; but there had been no extension on the new wood.

By October 30th two-thirds of the foliage was off, and the scale was apparently no worse than at previous accounts.

I have been inclined to charge the Bordeaux mixture with some of the injury to foliage, and am not sure that it was not to some degree in fault, though there was none of the characteristic spotting.

Tree 3—Black Tartarian Cherry. Was in full bloom and in fine condition May 3d, but made a very irregular set of fruit. May 25th, curculio marks became obvious, and on May 30th sprayed with full-strength Target brand Bordeaux and "Disparene." The application was duplicated June 12th, using Target brand arsenate of lead instead of "Disparene." July 4th the fruit remaining was ready to pick. The robins and the children had kept down all tendency to an over-burden of mature fruit, and what there was was of good quality.

August 18th the tree did not look so well as usual; there was considerable yellow in the foliage and quite a little dropping, a few shoots showing entirely bare. This dropping continued until well along in September, but then stopped, and on October 30th

it had scarcely fewer leaves than in September. Several colonies of web-worms started during September, but never got beyond the first leaf or two. Apparently there yet remained arsenate enough from the June application to kill all the young caterpillars.

Tree 7—Champion Peach. This is a ragged specimen which bore a good crop in 1906; was affected by rot that killed off some shoots, and was also broken. No cutting was done in 1907, and only the dead wood was cut out in early May. On the 3d of that month it was out in full bloom, and on the 25th had made a heavy set of fruit. Most of this dropped, but a very decent little lot came to maturity late in August and early September. About the middle of August the foliage of this tree also began to turn yellow, and some of it dropped. As no spraying of any kind had been done here there was nothing to account for this condition.

September 22d fully half the tree was dead, and I had the entire top cut out. There was no scale on the new shoots and very little elsewhere, with not a larva or recent set to be found. On October 30th the foliage was off or ready to drop, and on the live wood there was a heavy set of fruit buds. It was determined to allow the tree to stand another season and to shape it up as best could be done.

Tree 8—Baldwin Apple. This was set and has figured in previous reports as "Grimes Golden;" but when it fruited in 1905 it was recognized as something altogether different, and like No. 38. The fruit was not seen in 1906, but this year enough of it was allowed to ripen to make certain that it is really a Baldwin, which apparently does not reach its best development in my red shale.

The tree started well, but had very few blossoms and made only a light set of fruit. The old bark of the trunk was peeling off in flakes, exposing a clean, fresh surface below it. Only the merest trace of scale could be found.

May 30th sprayed with Target brand Bordeaux and "Disparene," full strength. June 12th the application was repeated, Target brand arsenate being used in place of "Disparene," and this application remained obvious for a month. July 23d made

yet another application, using this time the Vreeland arsenate of lead in combination with Target brand Bordeaux.

August 18th no scale was observable on the fruit, and there was little appearance of the ordinary fungus troubles, but there was a great deal of yellow foliage and many leaves had dropped. Late in September a few scales became visible on the fruit, and on the 29th of that month, as the premises were left untenanted for a few days, all the fruit was taken off to remove temptation to trespass, although it was not in real good condition to pick.

October 30th the tree was in excellent condition, foliage about half gone, the new shoots of satisfactory length, clean and free from scale.

Tree 15—Japan Golden Russet Pear. As this tree was not cut at all in 1906 it outgrew its trellised limits, extended much higher than I had heretofore allowed it to go, and had developed shoots directly away from the trellis. Some of the older branches had died, and when these were cut out not much of the original shaping remained. The supports were allowed to remain during the summer, but were removed in the fall. There was only a small bloom and a small set of fruit, which, however, developed well and was larger, cleaner and better than ever before. October 30th the last of the fruit was taken off; the foliage was yet almost intact, and there was no obvious scale on the new wood. This tree received no treatments of any kind.

Tree 16—Japan Golden Russet Pear. The record is in general that of the preceding, except that it is a smaller and poorer tree throughout and more hit by blight. Late in September a brood of scale larvæ and recent sets was observed on the old wood, but there was no general increase, and on October 30th, when the foliage was yet almost complete, the new wood was scarcely infested.

Tree 17 Trellised Peach. On May 3d this was one mass of large, showy blossoms. As there had been no cutting in 1906 there was a mass of long, thin whips, absolutely incapable of carrying a crop; but as I was curious to see what the fruit was like I allowed it to remain until late in September; then, as all the fruit had dried up or rotted and most of the foliage was already

off, I cut it out. Scale appeared on this tree in July, earlier than elsewhere among the trees; but there was no freer breeding, and in September the insects were no more conspicuous than in July.

Tree 18—Vermont Beauty Pear. This tree had been injured by blight in 1906, and there was a little in 1907 which was cut out when noted. The branches extend into the grape trellis, and the tree was invaded by the vine growth last year, so that, altogether, it needed considerable shaping up. It blossomed well and set a good crop of fruit, but, as 90 per cent. of it, at least, was infested by the larvæ of the pear midge, I had the entire set removed May 27th. One fruit escaped and ripened in late September, clean, nice, and free from scale.

The tree was sprayed with half-strength Target brand Bordeaux and "Disparene" May 30th, and received no other applications during the season. The yellow foliage and dropping of leaves manifested itself in mid-August here also, and growth had already stopped at that time.

On October 30th, very little foliage remained, the tree appeared to be otherwise in very good condition and scale conditions were satisfactory. On May 18th this tree had received 2 quarts of lime in 3 gallons of water, poured around the base of the tree.

Tree 19—Vermont Beauty Pear. In general way this tree is much like the preceding but poorer throughout. This fruit also was removed May 28th, and here also one example escaped to ripen in late September. The same lime application was made May 18th, and the same spraying with one-half strength Bordeaux and arsenate of lead was made on May 30th. On June 12th, however, this tree received an additional application of full-strength Target brand Bordeaux and arsenate of lead.

Scale conditions were worse than on tree 18. Breeding began early in July and a considerable number of recent sets were observed on the 4th of that month. Again, on September 22d larvæ and recent sets were found; but on October 30th matters were not at all bad. Most of the foliage was then gone; but there was little scale observable on the new wood and none of the old wood was at all badly infested.

Tree 20—Meech Quince. This tree made a slow start, bloomed sparsely and matured a small crop of fruit. There had been some blight in 1906, and there was a little in 1907 which was cut out as it manifested itself.

June 12th, sprayed with the Target brand Bordeaux and arsenate of lead, full strength, and this application was visible most of the season. There was very little scale at any time and no larvæ or recent sets were seen on the formal examinations.

October 30th, the tree was yet in full foliage and the crop was ready to pick: about two dozen specimens ranging from fine, smooth, good sized examples to little bruised runts. As to foliage conditions this remained in rather better shape than any other tree on the place.

Tree 23—Greensborough Peach. This is one of the lanky growing trees that need constant cutting back to get stout. No cutting was done in 1906, and in consequence there are only thin whips which early in May were set with large showy blossoms. It made only a moderate set which stuck well and supplied peaches from the beginning to the middle of August—a few each day. The fruit was of good size, fine shape, fair flavor and free from scale.

May 30th, it received a light and somewhat incomplete application of the half-strength Bordeaux with "Disparene." The foliage was rather small throughout the season and not of especially good color; but there was not much drop and it stuck well until the October frosts. On October 30th, it was almost all off and there was a good setting of fruit buds.

As to scale, there was not much of it at any time. On September 22d there was a small scattering of larvæ and recent scales, but when the last examination was made in October very few specimens were obvious on the new wood.

Tree 24—Greensborough Peach. This is a badly-placed tree and does not get much sunshine. In consequence it grows thin and lanky, the foliage poor in color and widely spaced and the trunk slender, out of proportion to the top. It was full of small dead twigs in early May when it blossomed out, and it made only a small set of fruit, most of which disappeared before it ripened.

Only a few good examples were picked during the early days of August.

May 30th, applied the one-half strength Bordeaux and "Disparene" lightly and not very thoroughly. The foliage became ragged and full of holes in July and August and dropped early. On October 30th, nothing remained; but there was a full set of fruit buds for next year.

Not until September 22d were larvæ and recent set scales noticed and even these seemed to have largely disappeared in late October.

Tree 25—Apricot. During the early warm spell this tree made a start that brought the blossom buds to the almost open stage, and then the ensuing frosts killed them off. Apparently a considerable brood of scales set on some of the bent branches in the shelter of the trellis, and, partly as the result of this scale injury and partly from the distortion caused, these shoots died off. Quite a bit of reshaping of the tree was required, however, and the trellis was abandoned. The fan shape, making it useful as a screen, was preserved by cutting.

On May 3d my note was: "There is plently of live scale to all appearance; but the long shoots of last year's growth are comparatively free." On May 18th, applied 2 quarts of lime to the surface around the trunk, in a 3-gallon pail. The tree made its usual vigorous growth, and in late September when larvæ and recently set scales were quite generally found, none could be seen here. On October 30th, it was yet in full foliage and apparently clean and free from live scale.

Tree 26—Nectarine. This tree was late in starting, blossomed very sparingly and matured only half a dozen very inferior fruits in early October. It grew well after it had started, however, and held its foliage as to color and condition throughout the season. On October 30th there had been scarcely any drop, and it yet appeared green and fresh.

As to scale there was little of it noticeable at any time during the year and at no period were there any larvæ or recent sets apparent. This tree had no treatment of any kind since October, 1905, during which year it was badly infested. Traces of that

infestation are still obvious in the rough scaly bark on the injured wood.

Tree 29—Gravenstein Apple. This is an excellent tree in all senses of the word: a little too much wood; but shapely and sturdy in development. It was a mass of flowers during the early days of May and by the 25th nearly all the flowers were off, some of the fruits were already well developed and in good condition to spray. Applied the Vreeland arsenate of lead, 2½ pounds in 25 gallons of water and covered thoroughly from all sides.

June 12th, sprayed with the full-strength Target brand Bordeaux and arsenate of lead, and on July 23d duplicated this application substituting Vreeland arsenate of lead for the Target brand.

Early in August quite a percentage of the foliage began to turn yellow and some dropped. The fruit was on the whole very good, all free from scale and very little of it wormy—in strong contrast with the record for 1906. Ripening began about the 10th, and a heavy wind brought down nearly a basket which were fit to use. By the 1st of September most of the fruit was ripe and a half barrel of it was picked off. Altogether, about a barrel of very good, clean apples came from this tree. But while the general condition of the tree was good the foliage was as thin as it should ordinarily be in early October. It grew no worse, however, and on October 30th about two-thirds of the leaves were off. As to scale very little was seen of it until September 22d, when larvæ as well as recent sets were found on the older wood where they apparently did nothing more, later.

Tree 30—Grimes Golden Pippin. This is another nice healthy tree, kept low and rather bushy in character; but vigorous and with more wood than it needs for its best interests. It blossomed sparingly and set a small crop of fruit, much of which dropped. During late June and early July the plum curculio attacked it in force, and many of the apples became distorted and knotty. Most of the fruit, about one bushel, was taken off September 29th, not because it was in the best condition, but because it looked too attractive to be left much longer, and I knew I could ripen it in store. There was no scale on any of it, and very little codling moth. In 1906 Mr. Dickerson's record was, on August 8th, "no

scale on fruit, which is nearly all wormy." The contrast is all to be credited to the spraying that was done.

June 12th, sprayed with the full-strength Target brand Bordeaux and arsenate of lead, and on July 23d repeated this application, substituting Vreeland for Target brand arsenate.

August 18th, some of the leaves had turned yellow and a few had dropped; but there was very little all told, and on October 30th it was yet in almost full leaf. At that time the few remaining fruits were taken off—now in prime condition.

Scale breeding was noticed on this tree, July 4th; but later it seemed to be much less in evidence, and on September 22d, when there was a general breeding, less was seen than in July. Very little was seen on the new growth in October; but there may be quite a lot of living specimens on the older wood beyond the range of easy examination.

Tree 31—German Prune. This tree made a good even start early in May; but blossomed sparingly and set fruit lightly; most of this falling victim to the plum curculio. The few that were left ripened in late September and were excellent.

No applications of any kind seem to have been made on this tree, and none seem to have been needed. Scale breeding was noted July 4th, and again on September 22d moving larvæ and recent sets were observed; in each case in small numbers. On October 30th only about one-fourth of the foliage was off, and while there was a scattering of scale noticeable on the new wood, there was not enough to make treatment seem necessary.

Tree 32—Mountain Rose Peach. A very nice little tree with long thin shoots. It blossomed early in May and made a very heavy set of fruit, most of which either dropped, shriveled or wilted, leaving only a small crop that reached maturity in late August; way behind the usual period.

This tree was not sprayed at all and could not well have received more than a small sprinkling from the spray meant for other trees; nevertheless, in early July much of the foliage turned yellow and dropped; more of it developed purplish spots with yellow borders, and most of this trouble was in the center of the tree. After midsummer matters improved somewhat, and on

October 30th the leaves were not yet all off, though ready to drop at a touch.

At no time during the season was any scale-breeding observed.

Tree 33—Dwarf Duchesse Pear. This is a tree that has never been really good for anything. It has served to test a great variety of insecticides and has been more or less scale-infected since it was put out. From one cause or another it has become of such an unfortunate shape that it was difficult to do anything with it. It had a few blossom clusters in May, but set no fruits. On May 30th it received an application of one-half strength Target brand Bordeaux and "Disparene," and on June 12th, a full strength dose of the same with Target brand arsenate of lead.

The foliage remained in good condition throughout the season, and while developing scale was noticed July 4th and September 22d, there was not enough to cause trouble at any time. Nevertheless, the general condition of the tree was such that I cut it down November 1st, while yet in full foliage.

Tree 35—Japanese Walnut. This tree continued to grow as rankly as usual, blossomed heavily, but set no nuts. Several broods of the black *Datana* developed during the season, and the caterpillars were mostly killed off when they came down and settled on the trunk in characteristic masses. Early in September I noted that web-worms were beginning to develop all over the tree, and as it had had no applications of arsenites at any time during the season, I had it sprayed with arsenate of lead (Vreeland) at the rate of 2 pounds in 25 gallons of water, on September 16th. A week later the larvæ were dead or had scattered, and the nests disintegrated without further increase in size.

Ocober 30th, the tree was completely bare and at no time during the season were scale larvæ or recent scales noted on it.

Tree 38—Baldwin Apple. An excellent, vigorous tree which made very long shoots in 1906, and came into bloom so gradually as to create the impression that the crop could not be a very heavy one. May 25th, all stages from blossoms to well-set fruits were present, and I sprayed from one side only, with the Vreeland arsenate of lead, 2½ pounds to 25 gallons of water. On the 29th I made a more complete application with 2½ pounds in 40 gallons of water, and on the 30th, as there seemed some

shoots at the top of the tree which were not hit, I sprayed once more to hit just those places.

June 12th, sprayed with full-strength Target brand Bordeaux and arsenate of lead, and drenched all save the extreme tips which I could not reach because of the rather high wind. July 23d, this application was duplicated, using this time the Vreeland arsenate of lead. A good crop of very nice characteristic fruit developed, and on September 29th, on the eve of a few days' absence from town all were taken off—not ripe but usable; in all about a barrel of nice sound fruit with the merest trace of codling moth and with some scale on about 20 per cent. of the specimens; sometimes only a single example, sometimes several. In no case were there more than a few and no fruit could have been by any stretch of imagination be considered as badly infested.

About the middle of August there was some yellowing of foliage and some leaves dropped; but not enough to affect the general appearance of the tree and on November 2d, there was little of it down.

Scale was found on the spring examination and always subsequently some living examples could be found; but it was not until September that breeding became obvious and then nearly everything was on the fruit. The marks there were easily observable: on the twigs it was almost impossible to find the insects.

Tree 42—Elberta Peach. A lanky little tree that has not made much growth and is poorly situated, close to 38. It made a nice start in early May, blossomed well and set some fruit, all of which dropped before it was ripe. It received quite a dose of the applications of arsenate of lead and of the Bordeaux mixture that was applied on tree 38, and the result was practical defoliation. Late in August it was mostly thin shoots, with little tufts of leaves at tips. On November 2d the leaves were nearly all off, and on the side next to tree 38 several twigs and one branch were dead.

As to scale, there was none seen at any time during the season.

Tree 43—Early Richmond Cherry. This is the same old straggling tree: not much increased in size nor in appearance. It blossomed in early May, made a fair set, and matured a small

crop of very poor fruit, most of which was taken by the robins without dispute by the children. May 29th, sprayed thoroughly with the Vreeland arsenate of lead, 2½ pounds in 40 gallons of water, and this application was incidentally duplicated next day. When tree 38 received its coverings of Bordeaux mixture this tree was almost as fully coated by the waste and blown spray.

Quite a bit of foliage turned yellow and dropped in July; but after midsummer there appeared to be a recovery and in September and October the tree looked better than ever before. On November 2d very little foliage had dropped, although it is all discolored.

There was little scale on this tree at any time during the season and only in late September was there any appearance of breeding.

Tree 44—Elberta Peach. This tree died during the summer of 1906, and was taken out April 15th because it had been invaded by the fruit-bark beetle.

Tree 46—Japanese Chestnut. This tree grows slowly and does little more than maintain itself. Apparently neither the soil nor the surroundings suit it and it is held merely as an example of this kind of tree for purposes of such experiment as may be needed. It made a late start in spring and set a few burrs which were opened November 2d and proved to be empty or with undeveloped nuts. Red mites and plant lice sapped the foliage which, however, held on throughout the season. It has never been scaly.

Tree 47—Greensborough Peach. This tree was over-burdened with fruits in 1906, some of the branches broke down under the load and the new shoots were allowed to develope as they would. It is therefore a poorly formed, unsatisfactory tree. The bloom was full, the set heavy and from it all developed a very decent crop of very fine fruit which lasted from about the beginning to a little after the middle of August.

To test the effects of the material on foliage I sprayed with the Vreeland arsenate of lead, 1 pound in 10 gallons of water, on May 25th. On May 30th, it received a partial dose of full-strength Target brand Bordeaux while tree 48 was sprayed. A little foliage yellowed and dropped in early July, but not much,

nor enough to affect the appearance of the tree. On November 1st, all the foliage was off and a heavy set of fruit buds had been made. At no time during the season was there more than a trace of scale and there was no breeding noted at any period.

Tree 48—Black Tartarian Cherry. Started out satisfactorily in spring and bloomed well, but was injured by frost, and there was only a small, irregular set of fruit. Most of this the robins secured, and the balance came off about July 4th.

May 25th, applied a thorough coat of the Vreeland arsenate of lead, 1 pound in 10 gallons of water. On the 30th applied a heavy dose of Target brand Bordeaux and "Disparene," full strength, so that the tree looked blue when dry. June 12th, this application was repeated, using Target brand arsenate in place of "Disparene." In early July some leaves began to turn yellow and dropped, and up to the middle of August this continued. After that time matters improved, and on November 1st the tree was yet in almost full foliage and in general good condition.

This tree was never scale-infested and is now free from this pest. In September a number of colonies of web-worms made a start, but never got further than the first leaf or two. It is interesting to note, in this connection, that the only tree on which these insects got a foothold is 35, which received no arsenical applications early in the season.

NURSERY TREE EXPERIMENT.

Out of an infested nursery block twenty-four of the worst infested trees were selected by Mr. Dickerson; twelve of them to be set out on the College Farm, twelve of them to be set out in my own garden. These trees were delivered on May 2d, and planted on May 3d. The trees on the College Farm were heeled in at once—those sent to my house were left without notice to me and exposed to the sun and air.

May 3d, I set nine of the trees that were in good condition, rejecting three that I believed would not grow. The varieties were Mt. Pearmain, Rhode Island Greening, York Imperial, Newtown Pippin and Ben Davis. All had started growth, the York Im-

perial less than the others; all were cut back moderately as to top and were set without root pruning, into holes large enough to take them easily. The soil was well packed around the roots and half a bucket of water was used to wash the soil into contact with the fine rootlets. As they were intended for temporary experiment only they were planted in two rows four feet apart and 5 feet apart in the row.

On the same day the trees were set out on the farm by Mr. Dickerson and Mr. Blake. These trees were set eight feet apart in a single row, were pruned root and top and were firmed into place with water. There were four trees each of York Imperial, Mt. Pearmain and Newtown Pippin.

May 16th, all the trees on the farm had made a start and around each was poured 1 quart of lime slacked in half a bucket of water.

May 18th, one Rhode Island Greening, and three York Imperial trees in my garden were treated in the same way. The soil was hoed away a little so as to form a basin, and the hot lime was kept from actual contact with the trunk. On the farm the field in which the trees were set was cultivated, and the trees received the benefit of that treatment. In my garden they were left undisturbed and received no care of any kind.

July 4th, all of my trees had taken hold and were growing except the single Ben Davis. The three rejected trees being also Ben Davis, this variety was left without representation. On some of the others the scale had just made a start, but on four of them there was not a sign of young as yet.

About this time two Mt. Pearmain and two Rhode Island Greenings were painted with "Avenarius Carbolineum," a material for which it was claimed, as it was for carbolic acid, that it would enter into the circulation and would thus kill the scales setting on the tree.

July 10th, the farm trees were growing well and were all in good shape except that they were more or less infested with plant lice. The scale had begun to breed on all the trees and recent sets were found in small numbers. There was no bad infestation in any case and only recent sets were noted; breeding had, evidently, just begun.

July 24th, Mr. Dickerson applied on two trees of each variety—York Imperial, Mt. Pearmain and Newtown Pippin, a band of carbolic acid, 60 per cent. The band was begun about a foot from the ground and was about a foot in width up and down the trunk. A good surface coating was applied but there was no attempt to saturate. At this time breeding had ceased except on one tree, and scales were generally in the black stage.

I kept a general lookout on the trees in my garden, keeping off caterpillars, etc., but not interfering with the plant lice, which curled the tips and soiled the foliage to some extent. All the trees except the Ben Davis took hold well and kept in pretty fair condition, although none of them made very much growth. This is due very largely to the character of the soil—red shale, without fertilizer of any kind, and partly, no doubt, to the fact that there was no cultivation, allowing a growth of grass and weeds about the base.

September 20th, there was little to choose between the trees so far as scale infestation was concerned. None of them were bad; but none of them were free. There had been just about what might have been expected from an infested nursery tree in a season that was so bad for the scale as this just past. The mid-September brood was the heaviest of the year and was about the same on all the trees. As between the limed trees and those with the "Avenarius carbolineum" there was nothing to choose. One set was as little and as much infested as the other and neither had harmed or injured the trees in the least. Results are absolutely negative.

As to the farm trees, these were examined by Mr. Dickerson, September 28th, and every tree was found scaly. None of the trees were very bad and on some the infestation was very slight. As all the trees had the lime application, differences in the amount of scale could not be due to differences in application unless the carbolic acid trees were uniformly different—which they were not.

The notes on the trees painted with carbolic acid are of most interest. Two of the trees are York Imperial. On both, there were many sets on the trunk, and some of them were on the very bark on which the acid was applied, so that the actual presence of the acid in the outer bark layer does not prevent the scale from

setting on it. On both trees the acid-treated bark had cracked on the northwest side, and for a space was dead, as were the shoots that had come from that area. While the upper part of the tree appeared to be still in good condition, a number of shoots were starting below the acid-treated area or at the surface of the ground.

One of the Mt. Pearmain trees was much like the two above described, and on this also, shoots were starting at the surface of the ground. The second was in much worse shape. Here the acid penetrated the bark on all sides and the top was dying because the girdling was almost complete. There was plenty of scale; more than on almost any other tree, yet not enough to cause any actual injury. New shoots had started from four points below the acid ring so that there is plenty of life in the root.

The two Newtown Pippins are apparently uninjured by the acid and both have done well. One of them has quite a setting of scale on the trunk, over the acid as well as on the untreated portion, while the other has only a sprinkling of scales scattered over the tree.

As to all these materials, it may be said that the applications were made too late, and that may be so. It proves, however, that they are not reliable when it comes to securing prompt action, and that despite either of them, a tree might be completely destroyed by the insects. The acid also is dangerous to young trees.

INSECTS ON SHADE AND OTHER TREES.

Interest in shade trees continues to increase in cities, towns and villages, and the number of organizations engaged in active work continues to increase. Morristown has been added to the number of those with organized commissions, and systematic efforts to preserve and improve the many fine trees of that city have been started.

On the whole city trees have suffered comparatively little from insect pests, although all the commissions and other organizations have an abundance of trouble to look after. The cottony and woolly scales on maples have been eliminated by natural enemies,

and it is doubtful whether either will ever again reach the same abundance in the municipalities with organized shade-tree commissions. The abnormal increase of the bag-worm is the most interesting feature of the year in this connection.

Elm Leaf Beetle.

Very little was seen of this insect early in the season and it was, in some cases, hastily decided that there would be no trouble from it during the summer. I was of much that same opinion myself from collections made at New Brunswick, and advised that it was not necessary to spray the trees on the College Campus. As to this the event justified my advice; very few larvæ were found later on these trees, but as for the rest of the city there was more injury than there has been for years past. And that seems to have been the experience pretty generally in those sections where the insect is troublesome. Comparatively few hibernating beetles were obvious, but there was a heavy oviposition and resulting larval brood.

The College elms were sprayed in 1906, and the difference in their favor during the present season was enormous. There were few adults early in the season and not enough larvæ afterward to cause the dropping of even a single leaf. Elsewhere in the town the foliage on every susceptible tree was so completely scraped that in September the foliage was dry and beginning to drop.

In other cities the small number of surviving beetles noted also gave rise to a false sense of security, which was rudely shaken when the developing larvæ began to make their work obvious. Not for many years has so heavy a brood matured as reached the adult condition during the season of 1907, and the outlook is for serious trouble in 1908, unless some adverse winter condition reduces the number of hibernating adults.

The condition in New Jersey was by no means different from that in other localities. In Massachusetts I found the insects even more numerous and the injury decidedly more marked. In Connecticut conditions were no better, and it would seem as if the

general climatic conditions between September, 1906, and May, 1907, were ideal from the standpoint of this species.

Arsenate of lead was quite generally relied upon to keep the insects down, and on the whole it did good work where properly applied.

The Bag-Worm.

This insect has been unusually abundant and destructive on shade and ornamental trees and shrubs in several sections—chiefly in the Delaware river counties. It has been more than normally troublesome everywhere, but in parts of Camden, Burlington and Gloucester counties it has become a genuine pest. Shade trees of almost all kinds suffered to some extent, the Norway Maple most of all, and, as usual, the Arbor Vitæ hedges and other conifers were among those most seriously affected. In some nurseries, indeed, the most active measures were required to prevent loss.

Just what caused this unusual abundance it is impossible to say with certainty, but that there seems to be no dearth of parasites is indicated by the breeding experiments carried on in the laboratory.

I noted large numbers of the young caterpillars early in the season on some orchard trees near New Brunswick, but the ordinary spraying operations sufficed to control these and little trouble occurred where matters were properly looked after. Apple and cherry among these trees were the greatest sufferers.

There is no difficulty in controlling this insect where proper measures are taken in time. A single application of arsenate of lead when the young begin feeding will serve to free the trees so completely that nothing more will be seen of them later in the season. As is the case with many other caterpillars, advanced growth results in greater resistance to poisons, and an application that will promptly kill the worms in the early stages will prove comparatively ineffective against caterpillars more than half grown. When they are almost ready for the change, in late August and early September, further applications are almost useless.

Some injury was done to Arborvitæ and other evergreens by spraying with Paris green; but with arsenate of lead good results were obtained.

For an early application soon after the worms have hatched, arsenate of lead 1 pound in 25 gallons of water or 1 pound of Paris green in 125 gallons of water, is ample. For the half-grown caterpillars 1 pound of arsenate of lead to 10 gallons of water will be required, while of Paris green 1 pound in 100 gallons will be effective.

On shrubs, hedges and small trees, collecting the bags in winter is still recommended as an effective measure.

To gain some idea of the relative proportions of the sexes and the percentage of parasitism, collections were made near New Brunswick and Mr. Grossbeck was put in charge of the work.

The specimens gathered were presumed to be fully grown and were not fed after they were placed in the cages. Altogether 1,335 bags were brought in during September and males and parasites began issuing soon afterward and continued to issue until late in October. The first male adult occurred September 16th, the last on October 15th. The parasite is a species very like and probably the common *Pimpla conquisitor* and of this the first example appeared September 11th and the last October 22d.

Three hundred and ninety-nine (399) specimens died in either the larval or pupal stage and some of these undoubtedly were specimens not quite full grown when collected and which were really starved. About twenty of these were males that died after the adult was actually formed and had not strength enough to get out of the pupal shell.

Two hundred and ninety-six bags produced male moths, and 347 contained fully developed females, most of which were never fertilized and died with undeveloped ova.

One hundred and seventy-seven (177) parasites emerged from male pupæ and 108 emerged from female pupæ, this excess of parasites in the males accounting for the greater number of female adults obtained. The eight remaining bags were infested by other parasites which apparently do not mature in fall. As against 643 bags that produced adults, there were 293 that pro-

duced parasites; not a large percentage of parasitism in a species that has the reproductive powers of the bag-worm.

In other localities the percentage of parasitism was greater: two correspondents, on Long Island, each gathered over two hundred bags and failed to secure a single adult male. Every specimen seemed to have been parasitized and the parasite seems to have been this same *Pimpla conquisitor*.

The Gypsy Moth.

Twice during the summer of 1907, I visited Boston and vicinity to watch the work done against the Gypsy Moth, and once I sent Mr. John A. Grossbeck to look over the territory.

The first of my visits was during the week of June 24–29 and was at the invitation of Mr. A. H. Kirkland to look over field conditions and at the methods of handling the parasite imported from foreign countries. The second of my visits was during the week of August 19–23, during the meeting of the International Zoological Congress and of the Entomological Society of America.

Both the Gypsy and Brown-tail moths are spreading; of that there is no doubt. The brown-tail moth has extended northward and eastward and has reached Nova Scotia. The Gypsy moth is following more slowly, but it has established colonies in Maine and New Hampshire to the north and in Rhode Island and Connecticut to the south and west. In the latter States its distribution is limited and effective means of control are employed. It is believed that there will be no spread from these points at present. In New Hampshire, Professor E. Dwight Sanderson, the Director of the Experiment Station, has the matter well in hand, and with the assistance of the Entomological Division of the United States Department of Agriculture is locating and trying to limit the colonies. With the work in Maine I am not at present familiar.

In Massachusetts the effort to exterminate has been abandoned. The brown-tail moth has spread so far and has such powers of spreading that no attempt to limit it stands much chance of success at present. The attempt to limit the spread of the Gypsy

Moth is more hopeful, and in this the United States Government is furnishing aid.

Over a million dollars have been appropriated by the State of Massachusetts for this work and compulsory legislation secures the co-operation of local municipalities. The result is a campaign unparalleled in extent, looking to the destruction of the insects not only in the towns and villages but in the fields, orchards and woodlands!

To the United States Department of Agriculture force has fallen the task of controlling the condition of some of the main roads and lines of travel to prevent the carrying away of caterpillars by vehicles, and especially automobiles.

But the most interesting feature of the work is the importation of parasites of both Gypsy and Brown-tail moths in simply enormous numbers. Dr. L. O. Howard, who is in charge of this branch of the work, has, during two years, secured in European countries collectors who gathered infested nests, larvæ, pupæ and egg masses and sent them to Boston, simply by the thousands. In the Saugus woods a farmhouse has been turned into a laboratory and surrounding this is a colony of tents, screen houses and sheds, containing cages of all kinds.

All the material received is carefully opened, its source and condition noted and the specimens are separated as may be needed and placed so that whatever parasites they contain may develop.

But that is not all: primary parasites are themselves subject to parasites and it is intended to prevent the introduction of these secondary parasites so as to leave a free field for the primaries. Everything is therefore secured in closely screened cages or in dark boxes in which holes are bored admitting light, but plugged by glass tubes. The parasites, when they emerge, fly toward the light and get into the tubes where they are readily seen and their characters recognized. Secondary parasites are invariably destroyed: the primary parasites are liberated under a system which is believed to give them the best chances for propagation.

There are many variations from this general scheme to suit special cases and, indeed, so far as possible each species secured in numbers is treated in such a way as seems best adapted to secure best results; but in general the scheme is as described.

It is too early as yet to judge as to the results of this work: two or three years certainly must be allowed for the importations to get a foothold and to make an impression. That these parasites will destroy or exterminate their hosts is not expected. The utmost that can be hoped is that they will keep down the injurious species to such numbers as to remove that constant threat of destruction to orchards and forests. It is an experiment unparalleled in its extent and aim: it deserves success. Meanwhile the usual destructive measures will be continued to prevent the insects from further overrunning the country.

We are not altogether without natural help even now, for during 1906 disease almost wiped out the brown-tail moths in some localities and reduced the Gypsy moth materially. During my June visit, fully half the caterpillars seen by me were diseased and in some places the percentage was much greater.

Up to the present time no signs of the insect have been found in New Jersey, and none have been found, so I am advised, in New York State. But we have through freight and passenger trains from Massachusetts into and through New Jersey, and the danger is by no means remote.

Cottony Maple Scale.

This is under almost absolute control by its natural enemies at present. It was almost entirely absent in those localities where it first became troublesome some three or four years ago and it lingers in only a few of the places where it last became abundant.

One of those places is at Rahway, and on July 11th, Mr. Dickerson collected a series of infested twigs. The infestation was not a bad one and was very irregularly distributed; but wherever the scales were found, there the lady-bird beetles were also present.

The collected specimens were examined in the Laboratory next day and larvæ were found in all stages, from those just out of the egg to those about ready to pupate: indeed, what were identified as eggs of the beetle were present on some of the masses.

The young larvæ, when hatched, therefore find themselves in the very midst of their food and dig at once into the cottony mass. For some time to come there will be little seen of this scale unless for once history does not repeat itself.

The Maple Pseudococcus.

This was scarcely noticed at all during the season of 1907. Even in localities where in 1906 it was very plentiful it was conspicuous only by its absence. Just what the conditions were that acted as checks I do not know; but in any case they were universal.

It will prove interesting now to find what happens to the signate lady-bird beetle which, last season, fed on this *Pseudococcus* after it had wiped out the *Pulvinaria*. The check to the *Pulvinaria* is largely to be credited to this little beetle; but the check to the *Pseudococcus* is not so to be explained.

Oyster-Shell Scales.

These insects have not been as troublesome as usual in most localities, and that period of abnormal increase, during which they threatened the life of maple shade trees in some sections of the State, seems to have passed.

Our winter applications against these insects have always been unsatisfactory. That period is passed in the egg stage, covered and protected by the dense female scale, and none of our insecticides have proved quite equal to getting through both scale and eggs. Washing the trunk with caustic soda or potash is an old remedy and quite efficient where thoroughly applied, but practically it cannot be put on well and strong enough except on the trunk and with a brush or swab. Very strong and caustic soaps have also given more or less satisfaction, and are more widely applicable.

During the winter of 1906-1907 some experiments made in England seem to indicate that the addition of kerosene to the

soap and soda will be effective. The formula that was said to kill all the eggs was:

Soft soap,	1½	pounds
Kerosene,	2	gallons
Caustic soda,	6	pounds
Water,	30	gallons

Emulsify the soft soap and kerosene with 1 gallon of water in the usual way, then add the soda and water to make up the full amount. Made up with a half pound of hard soap in the way usually recommended for the ordinary kerosene emulsion would probably answer just as well, and the material, when reduced and without the soda, would be a 1 in 15 kerosene emulsion—altogether too weak to reach any of the usual scale insects in winter form. The addition of the soda seems to open the way for the kerosene, not only through or beneath the scale, but into the egg as well. The formula is well worth trying.

The Periodical Cicada.

In the Report for 1906 I noted the fact that Brood XIV. of the Periodical Cicada, VIII. of my Report for 1889, had been practically eliminated in this State, and that not a single authentic record was received by me. Later I was informed by Mr. Marlatt of the United States Department of Agriculture at Washington, that a fairly reliable report had been received of their occurrence in Bergen county, so it may be that the brood still maintains itself with us by a slender hold.

No brood was scheduled for 1890, and yet in that year a few examples were reported from Staten Island, from Essex county, and from Anglesea. These records and others from New York and North Carolina induced Mr. Marlatt to enumerate a Brood XV., as an off-shoot from XIV., and made it a matter of some interest to note whether the insects would be present in observable numbers.

From Staten Island Mr. William T. Davis reported hearing the insects at two points 10 miles apart and taking several pupa cases. Personally, during a September ride through the Island,

I saw a number of trees which showed the characteristic, dead and broken tips indicating the egg punctures of this insect.

In New Jersey quite a colony occurred in Union county, extending from Plainfield to Westfield, and probably for some distance round about. This colony was reported by Mr. Davis, and on July 4th, Mr. H. H. Brehme collected a number of pupæ. One of the correspondents of the United States Department of Agriculture reported to Mr. Marlatt that he heard them several days in late June near Westfield.

Mr. Davis informs me that at Newfoundland, in Morris county, the insects were heard by an acquaintance whom he considers entirely reliable and familiar with the song of the species. This gives the species a somewhat greater range than previous records, but from the same general region.

On the other hand, the Essex county colony seems to have disappeared. None of the members of the Newark Society saw anything of them, and on July 1st, Mr. E. L. Dickerson spent the entire day in the wooded portions of the county without hearing a sound or finding any traces of adults or pupa-shells.

Nor could I get any trace of the specimens in Cape May county, either from observations made in June and July, or from late September examinations of tree tops. I spent two days in lower Cape May county in mid-September, and neither on Five-mile Beach nor on the mainland did I see any trace of the insects or their work. The same record must be made for Hunterdon and Somerset counties so far as I covered them on my various trips, and Mr. Dickerson, who has been in almost every county in the State in nursery inspection work, reports no signs of their presence. It is doubtful whether this brood will ever again be reported in New Jersey.

The next brood of these insects is due in 1911, and will be a large one.

INSECTS INJURIOUS TO FIELD CROPS.

Among the curiosities of the season was the almost total absence of potato beetles in many localities, and the generally small infestation throughout the State. In only a few localities were

the insects abundant enough to do any real injury, as against many where no spraying at all was done. The control agent was climate, not parasite or other enemy or disease. The early warm weather hastened the development of the hibernating forms, and the following cold and wet spell, long continued as it was, seemed to sap the vitality of the insects and caused their death. When, finally, the potatoes did get above ground the beetles were not on hand to attack them. The check is only a temporary one, of course; but it may be noticeable to a marked extent in 1908.

Cut-worms, while not so generally injured by the adverse climatic conditions, were also affected by it, and were not so abundant and destructive as usual. There were local exceptions to this of course, but that was the general condition.

On the other hand, as usual, a few other species found the season especially to their liking, and appeared in normal or even increased numbers.

Wire-Worms.

Wire-worms were quite abundant in a number of places during the year and a considerable variety of crops were attacked.

Mr. Dickerson came more directly into contact with them in the course of his cabbage-maggot work, and secured material for a number of laboratory tests.

"Killarvæ," "Antidin" and "Vaporite" were the materials used and, briefly stated, all the tests ended in one way—the wire-worms were not in the least injured. The method was to fill a battery jar nearly full of moist earth, stock it with a definite number of wire-worms, and put in two or three slices of potato as food. The cut pieces were forced down into the soil about two inches; but one end came to the surface for convenience of examination and removal.

The materials to be used were placed on the surface and washed down with water or were dissolved or suspended as the case might require.

"Killarvæ" was referred to in the report for 1906, and is again mentioned elsewhere in this report.

"Antidin" has also been mentioned in previous reports and

more extensive experiments would have been undertaken had it been possible to secure a supply of the material.

"Vaporite" is an English product put on the market by the "Strawsons" of London, and is a tar product of some kind. It much resembles an impure naphthaline and naphthaline is one of the ingredients. The material was well spoken of by Prof. George H. Carpenter, of Dublin, in his Reports, and at my request he sent me a sample. A representative of the Company called at the Laboratory during my absence from New Brunswick, so only the small sample sent by Prof. Carpenter was available for an experiment with the wire-worms.

In so confined an area the chances were all against the insects and any material used might be expected to produce its maximum effect. Nevertheless, Mr. Dickerson's notes show only one dead worm in each jar.

Incidentally, in the field, it was noted that the wire-worms fed on cabbages dipped in arsenate of lead and hellebore with as much relish and as little discomfort as on any others. On the other hand, the carbolic acid emulsion seemed to be quite as effective against the wire-worms as it was against the maggots.

Wherever wire-worms were much in evidence, moles were observed to follow and plants situated along the lines of their runs were found practically clear of infestation. At Riverton, robins were observed hunting about infested cabbage plants under such conditions as to make it almost certain that the birds were feeding on the worms.

The Army Worm.

Leucania unipuncta Haw.

The life cycle and a record of the occurrences of this species during the season of 1906 was published in the report for that year, and it was suggested that the absence of parasites on the specimens observed, might portend a greater number during the season of 1907. So far as the Woodbine locality was concerned, this increase did not occur—on the contrary, though Prof. Pincus promised to notify me promptly of the occurrence of any destruc-

tive numbers, there seemed to have been no trouble at all. In the State at large, however, the larvæ were much more abundant than in 1906, and chiefly south of Middlesex county. Several cranberry bogs were injured by them during the season and just after the middle of July, they appeared in Middlesex county.

On the 17th of that month Mr. Dickerson observed them in a wheat field of several acres, near Jamesburg, and feeding rather on the timothy sown in the wheat, than on the wheat itself. They were beginning to migrate to a corn field across the road, but were checked by a furrow plowed to protect it. Thousands of them perished in the hot dusty road. Others died in great numbers from a disease of some kind, and it was the rare exception to find one that did not have at least one parasite egg attached to the surface.

July 24th, report came that the caterpillars were present in numbers on the College Farm, and Mr. Dickerson found them in an oat field bounded on one side by a field of sweet corn, in charge of the horticulturist, and on the other, by a patch of field corn. Migration had begun in both directions, and the sweet corn had been sprayed with arsenate of lead as a measure of protection.

In the field corn two rows were badly infested and were suffering severely; the third row was less infested; the fourth was only slightly invaded, and beyond the sixth row there were few, if any.

This condition afforded an excellent opportunity to test the value of arsenate of iron, and on the 25th, at my direction, the infested rows were sprayed with this material at the rate of 1 pound in 80 gallons of water, using 2 quarts of glucose to add to the adhesiveness of the mixture. The application was thoroughly made by Mr. Dickerson through a "Friend" nozzle, and proved very effective.

On the 27th, the treated rows were examined and very few examples of living caterpillars were found. Here and there one or two examples would be seen on a stalk; but the bulk of the army had disappeared. In the sweet corn the arsenate of lead had accomplished an equally clean piece of work, and what scattering larvæ remained, needed no further attention; especially, as practically all of them were parasitized. There was no appearance of injury to foliage from the arsenate of iron.

There was no re-appearance of the caterpillars later in the season and everything points to a practical exemption for the season of 1908; or at least, until late in the summer of that year.

The Corn Worm.

This insect has been more abundant in South Jersey during the past summer than it has been since 1904. During the winter of 1903–04, the unusual cold resulted in the almost complete extermination of the species as recorded in my Report for 1904, on page 560. Since that time there has been very little complaint of injury, although it has been getting gradually more abundant each year. During the early summer of 1907, specimens of the larvæ were noticed on peas, and later on tomatoes, and, in some sections in the southern counties, material injury has been done to corn, both sweet and field.

We have made no advances in our methods of dealing with this insect in corn. Insecticide applications are not yet recommended, and nothing better than fall plowing of infested corn land has developed. This process is entirely effective, however, and plowing soon after the corn has been harvested and seeding with some cover crop is strongly urged wherever the injury is notably severe.

Sweet Potato Flea-Beetle.

In some parts of Cumberland county severe injury was caused this season by the sweet-potato flea-beetle, *Chaetocnema confinis*, a species which has not been especially troublesome in recent years. But the conjunction of unfavorable weather which retarded the plants and prevented their getting a start, with the beetle attack, was fatal. A very large percentage of the plants barely maintained themselves for a time and then died. The result was a very ragged-looking set of sweet-potato fields in September, and a decided shortening of the crop.

This is a trouble which can be almost entirely prevented by dipping the plants before they are set, in an arsenate of lead

mixture, 1 pound in 10 gallons of water. The adult beetles, which do the mischief, feed along the veins on the underside of the leaves and, on properly dipped plants, would succumb long before any injury could be caused. No spraying after the plants are set is as effective as the dipping, and as this is also effective against the golden beetles and their "peddlers," it is recommended as a general practice. Arsenate of lead will not injure the plants at any strength. Paris green is dangerous and should not be used.

Melon Lice.

Cantaloupes as a crop were a failure in most sections of New Jersey. They were retarded by cold in spring, by drought (locally) later on, and about the time they were ripening the cold nights destroyed that fine flavor that is usually a characteristic of the New Jersey crop. In addition to all these climatic troubles there were local outbreaks of the melon louse, chiefly in Burlington county, which aided in impairing crop prospects. It is some years now since there has been any widespread injury from this pest, and its occurrence during the past season can hardly be said to be threat of further increase next year; but it would be the part of wisdom for melon growers to be on the look-out for it early in the season of 1908 and to act promptly when the centres of infestion are first noticed.

Squash Bugs.

Not for many years have insects been so abundant on cucurbits, and among them the common squash bug holds an honorable position, so far as prominence is concerned. It was not until late in the season that the numbers became really large and, even then, there was no danger to the crop or vines. The danger exists in the large numbers that matured and went into hibernation. Should the winter prove a favorable one for them, they may become troublesome and injurious next spring.

Incidentally, while the opportunity served, a large number of examples was collected on the College Farm to determine whether

two allied species, which had been recently described, occurred among them. These allied species have occurred in New Jersey; but heretofore only as accidentals and not on the field crops. All the specimens examined proved to be of the common species.

Squash Lady-Bird Beetle.

This species also occurred in some numbers during the summer, but did no material injury. The adult beetles usually attract attention by their curious feeding habits, eating out little semi-circular areas at the margins of the leaves; but the yellow, spiny grubs, which really feed much more freely, are, as a rule, unnoticed. No trouble is to be anticipated from them.

Caterpillars on Cabbage.

The common caterpillars became extremely abundant late in the season and, where no spraying was done, very decided injury was cuased. So abundant were the white butterflies early in September that along the line of the railroads in South Jersey in some places it seemed as if from both sides a continuous shower of white paper fragments was thrown from the windows. I do not remember ever having seen this species more abundant; but, though very decided injury was caused, it was not in proportion to the number of the butterflies.

The truth is that cruciferous weeds of all kinds were also extremely plentiful, and there was plenty of food for all the caterpillars that hatched. The character of the season was, of course, primarily to blame for this, bringing the development of crops together in such a way that cultivation was perforce neglected for lack of help to do all things at one time. And when once the weeds do get ahead it is the exceptional farmer that catches up with them later in the season.

As for the cabbages most growers have found by experience that the arsenites, promptly and thoroughly applied, are both safe and effective. Paris green is the usual material, but arsenate of

lead is coming into more general use. In a few cases the poison was applied dry, the users claiming that it sticks better than a spray; and that is undoubtedly true when the application is made with a sprinkling pot or through a coarse nozzle. The addition of soap helps this trouble, and the forcible application of fine spray will usually leave poison enough on the outer leaves to prove effective. I have not been able to find that resin soaps have been employed, and those with whom I have spoken on the matter consider it too troublesome to make and too expensive to buy.

ROOT MAGGOTS.

The results obtained in a study of the onion and cabbage maggots in 1906 are summarized in Bulletin No. 200, published in February, 1907, and the details of observations and experiments made are more fully set out in the report for 1906.

During the season of 1907 observations were continued, and a few experiments were made to test some of the conclusions reached in 1906 and some of the methods of control recommended. The work was limited to the cabbage maggot and was chiefly done by Mr. E. L. Dickerson, following out the plans agreed upon with the Entomologist. The notes on field results were also made by Mr. Dickerson, who secured the continued co-operation of Mr. Howard G. Taylor, of Riverton, and induced Mr. W. E. Black, of Mercerville, to try some of the recommended methods. Whatever material appears in this account in quotation marks is from Mr. Dickerson's notes.

The erratic appearance of the maggot noted in the report for 1906 was very marked in 1907; some of the worst-infested localities of 1906 showing little injury in 1907, while some other places were much more troubled.

Mercerville Observations.

Mr. Black's cabbage patch consisted of "several thousand plants set in a yearling peach orchard, rows of plants being

Fig. 1. Placing tarred paper discs on cabbage plants, on Black farm.

placed between the rows of trees and the rows containing approximately 300 plants each."

April 5th the plants were being set out and the first of the experiments were made to test the effects of dipping the plants in arsenate of lead and in hellebore powder in preventing the maggot attack. In a pail of water one ounce of soap was dissolved; in this the plants were dipped, head down, as far as the roots, and they were then rolled in or sprinkled with the powdered hellebore so as to cover thoroughly, stems being particularly well treated. Nearly 800 plants were so treated, allowed to dry slightly so that the powder might adhere well and were then carefully planted. Nearly 900 other plants were dipped in the same way into a mixture of arsenate of lead at the rate of 1 pound in 3 gallons of water, a little soap being added to help its adhesive powers. These plants were also allowed to dry a little before being set, to allow the poison to set well on the surface.

On April 12th 300 tarred-paper discs were placed on as many plants. As the cabbage had been set rather deeply it was necessary to remove some of the surface soil so as to place the discs and get them to fit snugly around the stems. Nevertheless the work was done quite rapidly.

On April 26th adults of both sexes occurred in small numbers throughout the patch, and, as it was quite windy, they kept close to the ground. There had been quite a storm with heavy winds, and some of the paper discs had been dislocated or altogether torn off. "It was interesting to note that the discs had not prevented the cut-worms from working on several of the plants and destroying them." Neither the hellebore nor the arsenate of lead had injured the plants in any way.

April 30th, the flies were much more numerous and at one point a number of males were dancing in the air several feet above ground. Oviposition had begun and eggs were found on a number of plants, including some that had been treated with hellebore and arsenate of lead. None were found about the plants protected by the tarred discs. Some of the eggs were removed to the laboratory, where they were hatched a few days later.

May 8th, fewer flies were seen in the field, but these were yet ovipositing and many more eggs were found about the plants than at the previous record. "In a few cases the eggs were placed against the stems; but usually they were concealed under a small lump of dirt or elsewhere about the stem. Sometimes a dozen occurred in a single cluster and as many as 18 were noted about several of the plants. At this time, too, eggs were noted about a very few of those treated with the tarred paper discs, although in such cases there was more or less dirt over the discs." This dirt covering was due to cultivation, for while the attempt was made to keep clear of them, it was not always possible to keep the soil from being thrown on the papers. Recently-hatched larvæ were now found on a number of plants, and an occasional specimen was further advanced. A period of cold damp weather since egg-laying began had retarded development.

"One of the rows that had not been treated in any way was used experimentally at this time. The surface dirt was quickly removed from around the plants, and with it the eggs that had been placed there, and this was replaced by other soil. All this could be done very rapidly."

Near to the Black farm Mr. E. L. Riley had fields of cabbage and cauliflower which had been infested in 1906, and parts of these plots were sprayed with whale oil soap at the rate of 1 pound in 4 gallons of water. The odor of the soap was quite apparent for some time afterward, and Mr. Riley claimed that the flies were much less abundant where it had been used.

Several of the rows not under experiment on the "Black" farm were, about this time, sprayed with the carbolic acid and lime mixture described in the report for 1906. On May 10th, a second application was made on the plants previously treated, and the remaining rows, which had not been treated in any way, were given a dose of carbolic acid emulsion, after the surface dirt had been removed from the plants.

May 13th, some flies were still about, eggs were yet being deposited, and a few more were found on dirt-covered paper discs. May 18th no more flies were seen, but there were yet some unhatched eggs. There was a scattering infestation throughout the plot, but nothing bad anywhere, except on a couple of rows on the

further side of the field which had been left as checks—untreated and uncultivated. Here there was considerable infestation "and it was interesting to note that the maggots in many cases were found about or in the leaf-stems: due to the low planting of the cabbages." Incidentally a few wire-worms were observed feeding on the roots at this time.

May 28th, conditions had not changed much and throughout the patch, except in the check rows, the infestation was slight. In the check rows all stages from very recent larvæ to puparia were found and some of these puparia developed in the laboratory to the adult stage June 16-19.

June 24th, matters had advanced somewhat. There was no greater infestation than before and some of that was on plants dipped in hellebore and on those dipped in arsenate of lead. Adults were noted in the field, and on the flowers of some cabbages running to seed. The females had the abdomens fully distended with eggs, but none could be found about the plants. The majority of the insects seemed to be in the pupa stage and the conditions as to development were found identical on the Black and on the Riley farms.

During July the flies became first more numerous and then ever less abundant; but no eggs could be found either on the cabbages yet growing or on the stumps left after cutting out the head. Harvest began early in the month and continued into August. On July 25th, the flies had disappeared, leaving no infestation on these patches. On the Riley farm a patch of young late cabbage was as free from infestation as the old plants, but on some wild radish plants full-grown maggots were found.

August 21st, the harvest was over and the fields were cleaned up; the remnants showing no appearance of maggot infestation.

October 10th, a final examination was made and now, on the Riley farm, both turnips and radishes were found to be infested. The turnips were so badly infested as to be mostly unsaleable, and the radishes were not much better. It was interesting to note that there were many volunteer radish plants scattered about the place, and on a large number of these nearly full-grown larvæ were found.

The plots on the whole, on both farms, had been freer from maggot attack than might have been anticipated from the number of flies present early in the season and the number of eggs found. There was more infestation on the untreated rows on the Black farm, and the difference may be due to the treatments made. It may also be, in part at least, due to the fact that the untreated rows were not cultivated either, and therefore there was no disturbance of the eggs laid, at any time. The peculiar feature is the freedom of cabbage plants from injury during midsummer, although there were plenty of flies about, and the destructive increase of the fall brood.

Riverton Observations.

The area under observation here consisted of a small plot of several hundred plants set out by Mr. Taylor for the purposes of this experiment only. It was on the same ground used for the same purpose in 1906, and was infested territory. The plants were set just after the middle of April, and 600 of them were dipped: half in hellebore and half of them in the arsenate of lead mixture as described in the record for the Mercerville experiments.

April 23d, the plants appeared somewhat wilted from adverse weather conditions, but were otherwise in good shape. A day or two afterward Mr. Taylor applied tarred-paper discs to 25 plants not otherwise treated.

May 8th, adult flies were found active; many eggs were found about some of the plants and a very few of these had hatched. Wire-worms, however, were found working in considerable numbers, especially in one end of the patch, and considerable injury had already been caused. As many as 18 were noted about some of the plants.

May 15th, very few flies remained. Eggs, unhatched and in good condition were plentiful, and there were also many recently hatched larvæ. The infestation was evenly scattered throughout the patch, and "just as bad on the dipped plants as elsewhere. This treatment, therefore, has been of no apparent value, although it had not hurt the plants." Some of the recently hatched mag-

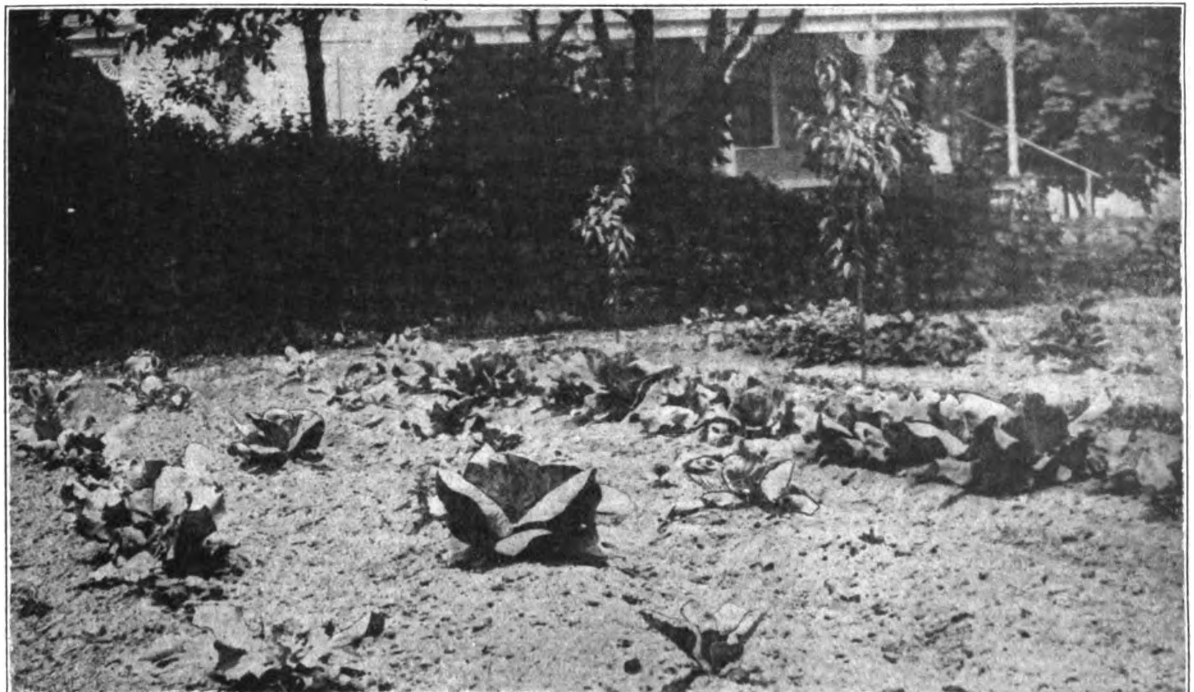


Fig. 2. Riverton Experiments. The large plants are those to which tarred paper discs had been applied.

gots had already penetrated to a depth of 2 inches beneath the soil. Wire-worms had injured the plants up to that time more than the maggots, and they in turn had furnished food for the moles. Mr. Taylor also reports noting birds, "which he believed were robins," working around the infested plants, and it is quite probable that they were feeding on these same wire-worms.

A number of infested plants were now treated with "Kill-larvæ," a material described in the last report. In all cases a cup-shaped depression was made around the plants to be dosed. In some the two powders that produce the active insecticide were mingled, placed in the cup, and water was poured in. In others the mixture was made up fully, and the liquid combination was poured into the cup. Rain interrupted the work, which was continued on the 16th by Mr. Taylor, as follows:

1. One dozen infested plants were taken up with the surrounding soil. The soil was shaken off, the plant was freed from attached larvæ and adherent eggs and then reset.

2. One dozen infested plants were taken up and cleaned as before, and half were then dipped in hellebore decoction—2 oz. of powder in 1 gallon of water—while the other half was dusted with the dry powder before resetting.

3. A cupful of the carbolic acid emulsion was poured around the base of each of one dozen infested plants.

4. Hellebore decoction—2 oz. in 1 gallon of water—was poured around the base of one dozen infested plants—one cupful to each plant.

5. Powdered white hellebore was placed around the base of each of 12 infested plants.

May 24th, the plants of the 1st experiment were a little wilted, but otherwise in good condition.

The plants of the second experiment were equally good and had not been injured by the hellebore treatment.

"The carbolic acid emulsion had penetrated the soil to some extent, had killed all those maggots with which it came into contact, and had not injured the plants. It is interesting to note that where it came into contact with wire-worms these also were killed. The hellebore decoction had penetrated less than the carbolic acid

emulsion, but appeared to have killed the maggots with which it came into contact."

Both the wet and dry hellebore had acted primarily to drive the maggots deeper down into the soil; but these as well as the acid were applied too late for the best results, and the insects were mostly out of reach.

"The best results had been obtained with the tarred-paper discs. On only one plant were maggots found working, although eggs had been observed about some of the plants so treated, early in the season, and this one exception was undoubtedly due to the fact that the discs were applied rather late. In addition, new roots had started near the surface of the ground below the cards."

June 25th, no more maggots were found, and no flies were yet seen, hence, as some puparia were present, it was concluded that the insects were mostly in that stage. Results of the maggot injury were now conspicuous, and the plants to which the tarred-paper discs had been applied stood out in sharp contrast to the others.

Thereafter the insects seemed to disappear, and when nothing new developed on July 15 and 25, the patch was cleaned up.

A number of other cabbage patches in the Riverton district were visited for the purposes of comparison, and all were found exceptionally free from maggot attack, in sharp contrast to the conditions recorded in 1906.

Husted Observations.

In the Report for 1906, the conditions found on the Seabrook farm near Husted are given in some detail. May 25th, it was found that while there had been some injury, it was not nearly so much as in 1906. "Cabbage had been planted on March 27th, and twice a week, thereafter, the dirt had been pulled away from the stems until a couple of weeks ago, when the dirt had been hilled up around the plants. Upon examination a few full-grown maggots and puparia were found, and a very few freshly-emerged flies were seen about the patch. Evidently many of the eggs had been removed by the process, and the few insects remaining were those which had been missed in removing the dirt. Tarred-paper

Fig. 3. Wild radish roots infested by cabbage maggots.

discs had been placed around some of the plants from about the stems of which some of the earth had been removed. The work was, therefore, a little tardy, and the plants appeared to be in the same condition as the others, save that new roots were making a fine growth under the discs."

General Conclusions.

The root maggots on cabbage were not, on the whole, nearly as abundant in 1907 as they were in 1906, although there were plenty of flies in the fields in April and May. Adults were first seen April 26th, and eggs a few days later. During the early days of May, flies increased in number, and then decreased until, soon after the middle of the month, no more of the first brood were found. Larvæ began to appear early in May, but were retarded in development by wet, cold weather, and pupation was not general until late in May. At Husted, in Cumberland county, the first adults were noted May 25th, but from puparia taken at Mercerville, in Mercer county, adults did not issue in the laboratory until June 16th. In the field, flies were noted until mid-July, although at that time in very small numbers. The late brood of maggots was in turnips and radishes, October 10th, at Mercerville, and the indications were that these maggots would not get beyond the puparia stage during the season.

Results of Experiments.

Dipping the plants in arsenate of lead or in dry hellebore was of little or no value. Plants so treated being as badly infested as any others.

Tarred-paper discs were distinctly effective. Several hundred were used all told, and, although eggs were found on some that had become dirt-covered, on only two plants were maggots found later. One of these cases is explainable by tardy application. The Husted work is not included here for reasons given previously. It seems that the eggs dry out on the tarred-paper surface and never hatch. The eggs were found only on those

discs that had become partly soil-covered in cultivating. "In this respect the work on the Taylor place was interesting. The plants where the discs were used not only made a better growth, on the whole, than the others, but with the exception of one plant they showed no infestation, while the plants immediately next to them on either end of the row showed it very distinctly. Judging by the results obtained there is no doubt that this treatment is thoroughly effective; but the discs must be applied when the plants are set, or immediately afterward, before egg-laying begins."

The cards used in our experimental work are a commercial article sold by W. H. Gassert of 49 Beekman street, New York City, at rate of two dollars per thousand. They can be equally well made at home as described in Bulletin No. 200.

Brushing away the surface soil from about the stems of the plants and replacing it with fresh soil removes the eggs laid near the plants to such a distance that the young larva, when it hatches, finds no food at hand and starves or dries up in its attempt to find a suitable plant. As the eggs are laid just beneath any surface shelter near by this brushing away and rubbing the stems of the plants is very rapidly done. Several hundred plants were treated in this way on the Black farm and very few eggs were missed. This work must be done within three or four days after oviposition begins, and must be repeated at 4 or 5-day intervals so long as flies are observed in the fields.

Carbolic acid emulsion prepared as described in the Report for 1906 and in Bulletin No. 200 is effective whenever it reaches the insects. It should be applied as soon as possible after the maggots have hatched and before they have gotten either deep into the soil or have bored into the plant tissue. It is better to form a "cup" around the plant to be treated so as to hold the mixture and force it to soak into the ground around the plant. It will require several applications to secure satisfactory results.

Carbolic acid and lime applied by Mr. Black on part of his patch was undoubtedly effective to some extent in checking injury by the maggots.

Hellebore in the form of a powder placed in a cup around the stem of the plants was not very effective. Hellebore decoction

applied like the carbolic acid emulsion was effective in that it killed all the insects it reached, but it is not so penetrating as the acid and must be applied even more carefully and more frequently to obtain satisfactory results.

Taking up the infested plants carefully, cleaning and resetting, works perfectly, and when plants are so badly infested as to show injury, or when the maggots are low down on the roots, this is about the only effective thing that can be done. On a field patch it is not a practical method. In the garden or on a small plot it is a satisfactory proceeding. Growth will be retarded for a few days, but no other ill-results have been noted.

Recommendations.

If cabbages are to be raised in infested territory, and injury is anticipated, nothing is better than tar-paper discs, applied when setting or as soon afterward as possible. If discs are not applied watch for flies in the field, and after these are noted look for eggs. When eggs are found in numbers brush away the infested soil from about the plants and replace it with soil that is clean. Or, a week after eggs are noted, apply the carbolic acid emulsion and repeat twice at intervals of five days. In any case prompt and thorough work is required, and too much stress cannot be placed upon the element of promptness.

These recommendations are based on the results of 1907 work only, and do not exclude the suggestions found in Bulletin No. 200.

The observations made late in the season emphasize the importance of getting rid of all cruciferous crop remnants and of all cruciferous weeds so far as possible. Late turnips or radishes, if they become infested, should be turned out and used or destroyed to prevent the maturing of a hibernating brood.

It should be realized that these maggots will develop on any cruciferous plant, and that we can never hope for clean cabbages if we confine our work against the insects to the cabbage patch.

MISCELLANEOUS.

The Rose Chafer.

This species was at least no worse than in 1906 and was probably a little less abundant. It was plentiful enough in many localities and caused considerable loss; but it was not so universally present nor so obtrusively noticeable in the field. I did not find it so abundant in the orchards and there were markedly smaller numbers on flowers. Grapes suffered more than other fruits, but even these were only locally affected.

Cranberry Insects.

While there is nothing new in the way of insect pests to be recorded, neverthless conditions of climate and temperature exercised so important an influence on the development of the usual species that injury was caused in spite of practice which, in ordinary seasons, is sufficient to secure exemption. At the ordinary period of drawing the water the weather became cold—very cold—and the hatching of eggs on the bogs was abnormally retarded. Vegetation started before the eggs hatched, and reflowing, done at the usual time, failed altogether to be of benefit because there were no larvæ to be reached. After the water was taken off the eggs hatched, and unexpected injury resulted. Some growers that reflowed very late secured good results; others that held the water very late secured equally good results. August 2d, I was on the Wills bogs in Burlington county and found the larvæ of the first brood just mature on the lower portions of the bog and adults in abundance on the higher areas—just one month behind normal conditions. The whole experience indicates the importance of observation in advance of practice. There is no use reflowing a bog to kill insects, until there are insects present in a condition to be killed.

Another new factor in the insect situation on cranberry bogs is caused by the practice of spraying with Bordeaux mixture to prevent injury from scald, rot and other fungus troubles. Sugges-

tions that bogs be sprayed have not been favorably received by cranberry growers in the past; but the demonstration that the destructive disease could be controlled has changed this attitude to a very marked extent. It adds nothing to the cost of spraying except the cost of the insecticide to add Paris green or arsenate of lead when applying the Bordeaux mixture, and this had already been done, with good results, by a few of the growers.

All the foliage feeders will be reached by this process, whether they are injurious or not, and whether they feed on the cranberry plant or on other bog vegetation. Grasshoppers, crickets and katydids are much reduced in numbers or altogether wanting on sprayed bogs, and a plant poison-coated will resist the later broods of even the black and yellow-head caterpillars.

Army-worm invasions, such as occurred in several bogs during the season, are impossible on sprayed bogs where arsenicals are applied with the Bordeaux mixture, and for lasting qualities arsenate of lead is preferable to Paris green and not much, if any, more expensive.

The Chinese Mantis.

This insect seems to have a precarious hold in several parts of the State; but has nowhere increased enough to become conspicuous. During the past summer single specimens have been seen, here and there, one of them in my own garden. No egg-masses have been found in any of the localities where the introductions have been made, and in some way conditions seem to be more unfavorable than in Pennsylvania, where the insect more than holds its own.

To the continued courtesy of Mr. Philip Laurent, I owed an additional supply of egg-masses in January, 1907, which were tied out by Mr. Brehme on Great Island and Bushtown, at the edge of the Elizabeth salt marsh, a totally different locality from those heretofore selected.

Nothing was seen of the insects during the summer, although Mr. Brehme made a special search for them late in the season; but when the foliage is all down, a new search may show better results in egg-masses. At all events not much can be expected of

these insects for some time unless they make an altogether new record for adaptability.

A New Importation.

During the inspection work in an Essex county nursery Mr. Dickerson was shown a specimen of a longicorn beetle, which had been captured there during the summer and, as it was unfamiliar to him, he brought it with him. It was equally unfamiliar to me, except that I recognized it as not native to the United States, and therefore I sent it for identification to Mr. Carl Schaeffer, of the Brooklyn Institute of Arts and Sciences. He made it out to be *Melanauster chinensis,* a common Oriental species, but could tell me nothing concerning its habits.

Inquiry at Washington resulted in the following letter from Dr. L. O. Howard, Entomologist to the United States Department of Agriculture: "Dear Doctor Smith: Your letter of September 18th had been turned over to Mr. Schwarz, and, after some delay, he submitted the following statement:

" 'It is not the first time that the *Melanauster* has been found in North America. Some years ago I determined the species for a California correspondent of this Bureau. It was found in Southern California, where it had emerged from a young fruit tree. I unfortunately forgot what kind of a tree it was, but it came from Japan, and had passed through the horticultural quarantine at San Francisco.

" 'There is nothing to be found in the literature available to me regarding the food habits of the genus *Melanauster.* There is, however, a figure in Professor Nawa's Journal, "Insect World," and there is probably an article referring to its life habits. Being ignorant of the Japanese language, I cannot read the article in question. However that may be, the genus *Melanauster* is closely allied to our North American *Goes,* which, as you are well aware, attack healthy deciduous trees, such as hickory, elm, etc., and occasionally do considerable damage. *Melanauster chinensis* is widely distributed in the Orient, occurring over the largest part of northern China, and being found extremely abundant in Japan.'

"I remember the California correspondent named by Mr.

Schwarz was Mr. S. A. Pease, from San Bernardino, who found that *Melanauster* emerging from a young orange tree imported from Japan."

ENTOMOLOGY IN THE CROP BULLETIN.

The season started with a memorandum in the April number, in which the Secretary of the State Board of Agriculture reviewed orchard conditions and stated that: "There are yet many good apple orchards, but many more are ruined by the ravages of the *San Jose Scale*." In the same number is a note from Preakness, Passaic county, that "Peach trees are all right and seem to be free from scale. Apple trees, in some places, are all right, and in others they are nearly dead from the scale." In the July number, Park Ridge, in Bergen county, notes that the "San José scale is not as active as in former seasons." In Piscataway, Middlesex county, on the other hand, "Fruits, owing to the scale, are very poor and not much of it." In August, Secretary Dye records that "There is a belief by some that the San José scale is not so abundant and is less destructive than heretofore." At Baptisttown, Hunterdon county, however, the note is, "Scale still destructive;" while Locktown, in the same county, bears out the Secretary's conclusion by the note that "The scale, so much dreaded, seems to be on the wane, and many fruit trees show signs of life and activity." In September, Hopewell, Mercer county, reports that "The scale is yet upon the fruit trees, and many have died since last spring; where spraying has been well done, it seems to have been effectual." In October, Riverton, Burlington county, reports that pears are "Not so much disfigured by scale as in former years."

Onion maggots are noted from Cedarville, Cumberland county, in the May number, as doing much injury to the crop; but that seems to be all that was noted concerning them.

In June "*Potato bugs* appeared in great quantities" at Woodstown, Salem county; but it is added that "the sprayer has done effectual work." In July a scarcity of the insects was reported from Layton, Sussex county; Park Ridge, Bergen county; Livingston, Essex county, and Locktown, Hunterdon county; all in

the northern half of the State. In August, Baptisttown, Hunterdon county, boasts "No Colorado beetles seen, having become apparently practically extinct." This is altogether a remarkable record for this common species.

The *Rose bug,* though it was common enough, was only referred to once, and that incidentally, in July, from Park Ridge, Bergen county, in the statement, "Grapes, where the rose bug did not attack the blossoms, will yield well."

Flies on cattle were unusually troublesome, and were referred to in July from Park Ridge, Bergen county, and also from Woodstown, Salem county, where spraying milch cows "with a carbolic acid solution has become quite popular."

Apple plant lice were reported as curling the leaves in July, at Livingston, Essex county, but seem not to have attracted attention elsewhere.

Cabbage worms first attracted attention in August, at Matawan, Monmouth county, where they were doing some damage. In September they had gotten to be "very troublesome" at Egg Harbor City, Atlantic county, and finally, in October, they were reported as having been very destructive at Blue Anchor, in Camden county.

Melon lice also appeared in August in numbers great enough to attract attention, at Mickleton, in Gloucester county, where they are associated with blight as causing injury to cantaloupes.

Grasshoppers were accused of eating cranberries in August, at Hammonton, Atlantic county, in September. Egg Harbor City, Atlantic county, reports "Cranberry crop light on account of grasshoppers," and in October another Hammonton report makes them in part responsible for a 25 per cent. shortage in the cranberry crop.

Fall web-worms attracted attention once only, despite their almost universal abundance. Hopewell, Mercer county, reports in September: "The caterpillar is weaving his web, and it is not unusual to see trees almost covered over; the most effectual remedy here is the torch, which is being applied."

INSECTICIDES.

The most conclusive and satisfactory tests of insecticides are those made in the field, under ordinary field conditions; but the applications should be made in such a manner and at such a proper time as to give the material tested a fair opportunity to do its work. I prefer, therefore, so far as possible, to test all materials sent me in the orchard or field and to make the applications under office supervision. Where a trial over a larger area is desirable material is distributed to farmers or fruit growers with whose methods I am familiar and whose statements as to what was done can be trusted, and even here I try to verify conditions and conclusions so far as possible.

The crucial test of any material is its use in the field by the average agriculturist or horticulturist and his help. A material that is effective under such conditions needs no other recommendation; but failure in them should not necessarily result in condemnation.

During the season of 1907 a few materials have been tested under office supervision; but a very large number of examinations have been made of results obtained in practical work and some of these are recorded here.

The Lime and Sulphur Washes.

These have continued to form the leading subjects of insecticide study and experiment throughout the country and on the whole, perhaps, their use may be said to be more general than of any one other scale-killer. They have not gained in favor in New Jersey, though they have fully held their own.

The summarized results of practical experience and of experimental records may be set down as follows:

Any combination of lime and sulphur, no matter how produced, so long as all the sulphur is fully combined with the lime, is effective as a killing agent against the San José Scale.

Practically, in the hands of the average fruit grower, the boiled mixture has proved the most reliable and the results have been best.

Salt is not necessary to the mixture, adds nothing to its killing qualities and nothing to its mechanical condition. On the matter of adhesiveness there is some conflict of opinion; but the weight of evidence is that no material advantage is gained in this direction. Salt may be omitted altogether from the combination.

If the lime is good, one pound is more than enough to take up one pound of sulphur; if there is any considerable percentage of impurity it requires more, so as to get a sufficient amount of actual lime. With lime of such ordinary good quality as is obtainable throughout New Jersey, one pound is sufficient for use with every one pound of sulphur. Any excess of lime is mere whitewash, adds nothing to the killing quality of the combination, makes it thicker, more difficult to apply, and renders it less able to get into crevices.

Hot washes spray easier than cold, seem to be more fluid and penetrate better for that reason; they are not more active as insecticides than when cold.

Thoroughness in application is essential. No scale not actually hit by the wash will be injured by it, and the wash has practically no spreading power. Given a properly prepared mixture, the problem of killing all the scales on a given tree is purely a mechanical one. A coarse spray put on with little force is apt to make a coating *over* depressions and plant hairs, and though a tree so sprayed may be entirely white, it is quite possible that considerable areas of surface may not have any material in actual contact with it. Such applications are apt to scale off long before the breeding season opens. A fine spray driven against the surface with great force will get into cracks and crevices and through considerable surface vestiture.

Flowers of sulphur or flour of sulphur (ground) may be used with equal effect; but the flowers of sulphur being very much finer combine more readily with the lime, hence it requires a shorter period and less heat to secure a perfect combination. The wash cannot well be overboiled; the danger lies in not boiling enough.

There are a number of incidental advantages in using the lime and sulphur mixtures that turn the balance in their favor as against other equally effective scale-killers and the greatest of these is its fungicidal quality. There is no doubt of its effective-

ness in this direction, although just how valuable it is, is not so well settled. It has been rated as equally effective with the Bordeaux mixture for winter application; but that does not seem to be borne out as to many cases. For peach troubles it does seem to be almost a specific, and it does no doubt exercise a controlling effect upon peach-leaf curl. But I have seen during the past season in Hunterdon county several orchards sprayed with lime and sulphur and yet very badly affected with curl. As the trees were also in some cases quite scaly, there is a possibility that the mixture was not a satisfactory one. As a general thing it may be said that on peach trees the lime and sulphur mixtures seem to act as a stimulant and to the improvement of their general health. It has little apparent effect upon the rot, however, so far as my observations extend.

It is more than likely that as against any diseases the spores of which lodge on the outer surface of the bark, the lime and sulphur mixtures will prove more or less effective and perhaps, in most cases, not much less so than the copper mixtures.

As against other insects, the lime and sulphur combinations are effective in the case of armored scales similar to the San José, and passing the winter in the partly-grown condition. They are much less useful or altogether useless against armored scales passing the winter in the egg stage, like the oyster-shell bark-louse; and they are of no effect against the soft peach-scale. In the case of thin scales like the scurfy scale, they answer quite well even though these hibernate in the egg stage; but against the thick covering of the oyster-shell scale I have found the material of little avail.

On the other hand the eggs of plant lice seem to yield quite readily to the washes, and it has been said to destroy the pear-leaf blister mite—which is quite in line with the known effects of sulphur against mites in general.

One cannot go very far wrong in using the lime and sulphur washes on orchard trees of any kind, whenever there is anything within their range to be dealt with; provided their limitations are kept fully in mind.

As to formula and method of making, I have seen no reason to

change my previous recommendations. Use lime and sulphur in equal weights and use three gallons of water for every pound of sulphur. The boiling is decidedly favored as the best method of uniting the lime and sulphur and the reasons for that have been given at length in previous reports.

Rex Lime and Sulphur Solution.

One of the serious objections to the lime and sulphur mixtures is the difficulty of preparing them and the boiling and other outfit required. There have been several commercial preparations, ready to use or concentrated and to be diluted, and I have tested all of them that have come to my notice. None proved satisfactory in my hands and as my experience was identical with that of others, the preparations made no way and were short-lived.

At the same time there seemed no good reason why a commercial preparation should not be a possibility, and so, when the "Rex Company," of Omaha, Nebraska, advertised their preparation and referred to the Entomologist of the Washington State Experiment Station in confirmation of their claims, I decided to test the material in New Jersey. I made certain first that the reference given was justified, and my correspondence seemed to indicate that there might really be a substitute for the home-made mixture.

I ordered and received 7 barrels and paid almost as much for the freight as I did for the material which was divided as follows:

To the College Farm,	1	barrel
To the Dickerson peach orchard, at Chester,	2	"
To Jos. H. Black, at Hightstown,	1	"
To Horace Roberts, at Moorestown,	1	"
To Clayton L. Andrews, Moorestown,	1	"
To W. P. Pray, Kinkora,	1	"

The material used on the College Farm could not be considered in estimating results, because the infestation was altogether too slight to make the trees fair subjects for experiments. However, in late September the trees were all in good condition and there was practically no scale. There was certainly no increase over

spring conditions; but owing to the character of the season and the fact that the scale in this section increased very little at worst, it is not fair to credit the Rex mixture with the condition found.

On the Dickerson peach orchard there are between 500 and 600 bearing trees of good medium size, which have been scale-infested for several years and were treated in 1905–06 with Scalecide. This kept the insects in check and the trees in good condition; but there was sufficient infestation to make spraying a necessity during the winter of 1906–07. One barrel of material was opened in January but the temperature was so low that the mixture froze in the hose and work was perforce abandoned.

March 28–30 conditions were better and most of the trees were thoroughly sprayed under the immediate direction of Mr. E. L. Dickerson, using 5 gallons of material in 1 barrel of water: *i. e.*, 1 part to 9 of water. In the barrel that had been opened in January there was some crystallization; but the crystals dissolved completely when stirred. Goulds Pomona pump with 2 leads of hose and single vermorel nozzles were used and a very thorough piece of work was done.

July 20th, a careful examination was made; the gray color due to the Rex mixture was still obvious and larvæ and new sets were very hard to find. The results appeared excellent and there was promise of a fair crop of fruit.

September 30th, a final examination was made and the trees were found to be in a thoroughly satisfactory condition. Some trees seemed to be entirely free from scale and on others there was a mild scattering along the branches. Nearly 400 baskets of fruit had been sold out of the orchard which, so far as scale is concerned, is in much better condition than it was in spring when the application was made.

Conditions elsewhere in the vicinity showed a normal increase in scale development so that it is fair to credit the mixture with the results noted. The examination being made so late in the season showed the worst that could happen during the year.

The material sent to Jos. H. Black, at Hightstown, was applied largely to an orchard of peach trees so badly infested with scale that they were to have been taken out as useless. The request that an experiment be made determined Mr. Black to leave

them for this purpose and they were thoroughly sprayed in early April from two ways. The results were all that could be expected. On August 15th, Mr. Black advised me that there was scarcely any live scale to be found. What little did occur was mostly on the young suckers that started near the ground. In September I saw Mr. Black personally and was assured that the conditions had not changed; the trees were still as free as they had been three weeks previously. The application was at the rate of 1 to 10.

To test the possibility of using it as a summer application Mr. Black sprayed some rows of nursery trees in June, using 5 gallons of mixture to 100 gallons of water, and this did not injure the foliage of even peach trees. As to the effect of the mixture at this strength on scales, nothing was determined. It might kill larvæ and recent sets. I would not expect very much of it against the well-set forms.

Mr. Horace Roberts applied the material on peach, pear and plum and on a considerable number of trees, and these trees I looked over early in July just before the summer meeting of the State Board of Horticulture. Mr. Roberts had also used Scalecide, the soluble oil made by the Thomsen Chemical Company and the boiled lime and sulphur wash. There was thus good opportunity to make direct comparisons and the Rex mixture showed results that fully equalled if it did not exceed any others.

The examination was really too early to determine just how much benefit had been derived; but it was comparative, and at the end of the season Mr. Roberts was sufficiently well satisfied with the outcome of his experiment to order a carload of the "Rex."

The material sent to Mr. Clayton L. Andrews was applied as follows: "The latter part of February we sprayed a lot of peaches with the mixture one to ten. The last of March, sprayed again, one to twelve; also some trees one to ten. The fifteenth of April we painted a lot of apple trees with the mixture one to twelve." August 7th, all the trees were reported as satisfactory except the apples—there was some scale on them.

I went over these trees myself, with Mr. Andrews, August 15th, and the results on the peach trees were certainly all that could be desired and in comparison with other applications equalled the best results from soluble oil. The apple trees were young, some

of them very scaly and the painting had been done in a very sloppy manner. The conditions did not speak well for the material, assuming that the application was properly made.

Mr. Wm. P. Pray gave the following account of his work: "Have applied the Rex Lime and Sulphur solution to the following, between March 21st and 25th:

100 apple trees,	12	years	old,	sprayed	from	3 sides.
120 quince trees,	6	"	"	"	"	2 "
150 peach trees,	4	"	"	"	"	2 "

Of about 40 of the above apple trees some were cut back 2 years ago on account of scale, and others have not made the growth they should have for their age. I think I covered them all pretty thoroughly."

August 26th, I visited Mr. Pray's orchard and looked over the treated trees. The quince may be eliminated from consideration because not sufficiently subject to scale injury; but the apples and peach trees had certainly been sufficiently coated to make them good subjects. The results here again were all that could be desired and even on the apple fruits, scales were scarce and present only in small numbers.

At the winter meeting of the Association of Economic Entomoligists in New York city, it appeared that several of the members present had used this combination experimentally and with good results, in comparison with the boiled mixtures.

On the whole, then, the result of such information as has been secured and of the experiments that have been made, point to the fact that the Rex lime and sulphur solution is practically as effective as the home-made mixture when diluted with 9 times its bulk of water. It seems to keep for months even after the barrel is opened and need not be warmed before applying.

This material will not supplant the home-made mixture for large orchards and it will do no more or better than the home mixture on apple and pear; but it will reach the owner of a few peach and plum trees who does not want to go to the expense of procuring a boiling outfit or the trouble of making the mixture.

As to cost, exclusive of freight, it is only a little more than the home-made mixture; but the cost of freight from Nebraska

almost doubles its price. I have had some correspondence with the manufacturers and have urged them to arrange for a local distributing point in New Jersey, and this suggestion has been favorably received but has not been acted upon at present writing so far as I have been informed.

Soluble Oils.

This subject, so far as it refers to commercial preparations, was dealt with at some length in the report for 1906, and there is not very much to be added in the matter of directions.

"Scalecide" is still the most generally used of these materials and its use is increasing faster than the general percentage of increase of those using insecticides against the pernicious scale. Effects have been quite satisfactory on the whole where the 1—15 mixture was used and almost perfect results have been attained in many cases with two sprayings.

A great many orchards—chiefly apple and peach—were examined by Mr. Dickerson in Hunterdon, Warren, Sussex and Morris counties on special trips intended only to get the fruit growers' experience, and I have seen many orchards myself, chiefly in the southern counties, of apple, pear and peach.

Good results were almost universal; failures were few, but did occasionally occur, and perfect results were even more rare. It has been definitely demonstrated, however, that actual extermination is possible with soluble oils on even large apple trees, while there is no particular trouble about keeping the insect in check.

A long enough series of years has now elapsed to make it safe to say that no harm is caused to trees of any kind by repeated applications of soluble oils, and that they may be safely used as often as may be needed. Nothing remains on the bark that can not be either evaporated or washed away, and there seems to be no penetration through the outer bark and into the bast tissue.

A distinct value as a fungicide has been demonstrated in the case of those peach orchards in Hunterdon county that were in the "leaf-curl" area. Trees sprayed with "scalecide" had

much less curl than others of the same variety unsprayed, but the results were not so good as those obtained with the lime and sulphur. On yellows I could not find that there was any effect whatever. Nor could I find any effect on the rot, or on any of the diseases of the apple or pear.

I have seen no reason to change my opinion as to the value of these oils, but have been rather confirmed in it by another season's observation.

In one point it has proved itself superior to lime and sulphur, even on peach trees. Many nurserymen are fixed in their belief that fumigation is injurious to buds and they prefer to run the risk of budding in scale rather than treat their budding wood in this way. Absolutely clean sources of supply are rare now-a-days and nurserymen quite usually spray in the bud to avoid infestation. Trees are very apt to become dirty so near the surface of the ground, and in such places the lime and sulphur mixtures will not stick nor reach the insects. The miscible oils find this dirt no barrier to their effectiveness; they penetrate readily and come into direct contact with the insect beneath. This feature was brought out in the course of our nursery inspections this year.

Home-Made Miscible Oils.

Since it was practically demonstrated by the commercial products that the petroleum oils could be prepared in such a way as to be readily and easily mixed with or dissolved in water, and it was further found that such "soluble oils" were satisfactorily effective and not harmful to trees, there has been an increasing demand for some method of preparing them at home, at a less cost than is charged by the makers of the commercial materials.

In my own work I have proceeded on the assumption, based upon experience, that the average farmer and fruit grower preferred to buy an insecticide all ready made, to going to any considerable trouble to make it. Therefore I rather endeavored to influence manufacturers to make and market a reliable commercial product filling all the requirements of a satisfactory insecticide.

In the Delaware Experiment Station experiments have been made, carried on for two years or longer, looking to the discovery of some method of producing a home-made material at a less cost, and in Bulletins 75 and 79 the results of their experiments are published by Mr. Charles L. Penny, the chemist who made them. It is obviously beyond the scope of this report to go into any detail as to what has been done in Delaware; but by permission of the Director of the Delaware Station the following directions and formulas for making the combination that has been found most effective are presented; quotations being in all cases from Bulletin No. 79 of the Delaware Station.

In making a soluble oil, it is necessary first to have an emulsifier, which may be kept in stock when once made and used as needed to prepare the oil for spraying purposes.

"*Making the Soap.*—After considerable experience we have not been able to find anything better as an emulsifier than the soap made from menhaden oil, or fish oil, and potash, with carbolic acid added to help the solution. This soap seems to answer most purposes better than any other, and is easily made. It is described in Bulletin No. 75, under the first part of Formula No. 8, which is here repeated as Formula No. 28.

The "Soap Solution."

FORMULA NO. 28.

Menhaden Oil,	10 gallons
Carbolic Acid,	8 gallons
Caustic Potash,	15 pounds
Heat to 290° or 300° Fah., then add at once while still hot—	
Kerosene,	14 gallons
Water,	22 gallons
Cost, after addition of kerosene and water: 15.7 cents per gallon.	

"The caution given before may well be repeated here, viz., that this mixture is inflamable when hot; and disagreeable fumes are given off from the carbolic acid. Hence, for comfort as well as for safety, the operation should be conducted out of doors, or at least with good ventilation and freedom from fire risk. A suit-

able vessel for the boiling is a deep iron kettle, such as is used for heating water. Of course, its size should depend on the amount of soap to be made; a capacity of 25 or 50 gallons is usually suitable, though generally the larger the better, since it should not be much over half full to provide against foaming.

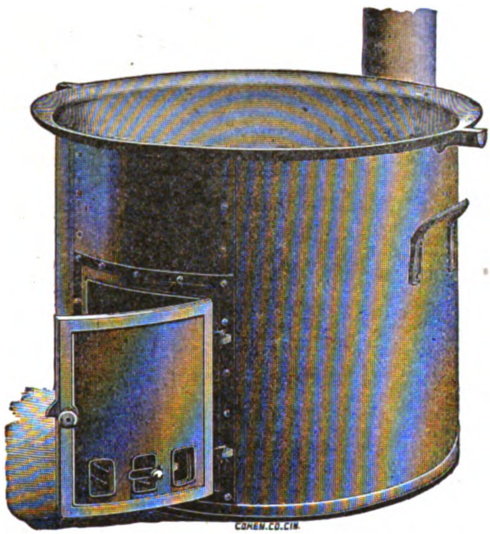


Fig 4.

A combined furnace and kettle made by the Philadelphia Farmers' Supply Company. Electrotype by courtesy of the company.

"A kettle and furnace combined, for use with a wood fire, is shown in Fig. 4. This is offered by the Philadelphia Farmers' Supply Company, 1916 Market Street, at the following net prices:

30 gallon size,	$9.88
40 " "	11.40
53 " "	13.68
65 " "	15.20
75 " "	18.24

"Covers may be purchased for any size at a slight additional cost.

"The kettle should be covered by boards, or otherwise, to prevent the mixture from taking fire. A thermometer passing through a hole in the cover affords the readiest means of determining the progress, and finally the end, of the operation. When

the temperature approaches 255° or 260° Fahrenheit, foaming begins and continues until the temperature approaches 270° Fahrenheit. During the most active foaming the fire must be checked somewhat by withdrawing a part of it, or otherwise, as throwing sand on it. After the foaming partially subsides the fire is increased until the temperature of 300° Fahrenheit, is reached, when the fire is withdrawn and the soap is made. Overheating a few degrees—10° or even 20°—does not spoil the soap, but it should be avoided as it increases the fire risk. At the beginning it is best to stir the mixture with a stick or an iron rod, to keep the potash from caking on the bottom of the kettle, but it is unnecessary to continue this after the mixture is warm. A small wood fire is sufficient to boil a kettle full. The operation may last from half an hour to an hour. After the fire is removed the requisite amounts of kerosene and water are added to the hot soap mixture, very conveniently in an open barrel, to which the soap has been transferred, the *kerosene always first,* since otherwise there is danger of an explosion from pouring water on the hot oil. The whole is then thoroughly mixed by stirring. It should form a uniform liquid, very slightly ropy, and without any separation, on standing, into layers, fluid enough at the freezing temperature to pour readily, and a portion mixed with a large volume of water, five or ten times its own volume, should dissolve to a uniform liquid, perhaps a little turbid, but without any free oil. The soap thus made seems to suffer no deterioration from age or exposure to the air. A sample kept for eight or nine months in an open barrel was found unimpaired and unchanged. It does not separate into parts on standing, and hence when once made it requires no further mixing.

"In place of potash it is possible to use caustic soda, but it hardly seems to be advisable. The reaction with the soda is less active than with the potash, and frequently a residue of soda is left unacted on, so that the proportion of alkali is somewhat uncertain. While the soda is cheaper and often easier to obtain, the potash seems to be preferable. If, however, soda is used, the weight should be about the same as given for the potash and care should be taken that the soda is all dissolved. But soda is not recom-

mended. All of our experiments have been with the potash soap and at present, at least, we cannot advise the use of any other.

"The object in adding the kerosene and water to the soap is partly to keep the mixture fluid. The soap proper, that is the mixture before the water and kerosene are added, is quite solid when cold, and hence, to dissolve it in the various oils would require either heat or a long time, both requirements quite inconvenient. But in a liquid form it mixes with the oils readily. There is the further advantage that out of a number of proportions tried, the one given seems to make the best emulsions. It will be seen that the final mixture, hereafter to be called the 'soap solution,' only one-third is soap and carbolic acid, the remainder being kerosene and water. This, of course, requires larger containers. If it is preferred, the kerosene and water may be omitted, and the soap and carbolic mixture may be prepared in the form of solid bricks, to be melted when they are mixed with the oils. This would save much in the cost of packages but would be far less convenient as heat would be required, whereas the 'soap solution' mixes readily with oils in the cold. Whenever in the following formulas 'Soap Solution' is called for, the complete mixture with kerosene and water is meant.

"*Mixing the Soap and Oils.*—The 'soap solution' as just described may be mixed with a number of different oils, and usually some water, in such proportion as to give emulsions. The process of mixing the soap and the oils is simple; it is carried on without the application of heat, merely with agitating in suitable vats or tanks. If the materials are very cold, as in winter weather, the mixing is sometimes a little more difficult, especially in respect to resin oil, which becomes rather too viscid to mix readily. Thus it is a little easier to make a thorough mixture in a moderately warm room than a freezing temperature, but with good agitation mixtures may be made at any temperature at which the oils will run.

"It will be noticed that in most of the formulas water is called for, but the amount is not specified. This is because different samples of several materials such as the menhaden oil, the resin oil, the paraffine oil, etc., do not always give just the same results when mixed seemingly in the same way; and more than this, with

the same materials it is not always possible to get miscible oils exactly smilar in every way. There are slight differences in the making of different lots, according to the same formula and from the same materials, that give to the final product different characteristics. Probably temperature is one of the varying conditions, a slight change in proportions may be another, and again the thoroughness with which the ingredients are mixed may be a third.

"The proper amount of water to be added in mixing the oil is best determined by trial in each case. When the soap solution and all of the oils called for have been well mixed, a small sample of the product, as a spoonful, is tested in a glass of water. In the case of some formulas there may be an excellent emulsion, without any free floating oil, but in most cases there will be no emulsion at all. A gallon of water usually (for the quantities given in the following formulas) is then added and thoroughly mixed with the oil, and a second test is made. Probably several tests will have to be made and several gallons will have to be added before a satisfactory emulsion is obtained. A little experience will soon teach how much water is required for a particular formula under the prevailing conditions, and then the proper amount of water may be correctly estimated and added at once.

"The proportions named in the following formulas are expected to permit perfect emulsions when the preliminary amount of water has been determined and added. Nevertheless, in the use of these or any miscible oils it is just as easy to add at first to the amount of oil to be used about half its volume of water, to mix well, and then to pour this into the remaining portion of water. This is safest as a uniform practice in all cases, though in most cases it may not be necessary. It will sometimes secure an excellent emulsion where there has been failure without this precaution. The value of water in securing emulsions has been more fully discussed in Bulletin 75 under the head of 'Manipulation.'

"In the making of these oils no regard need be paid to the order in which the ingredients are added, except that the water, if any, is always to be added the last of all, after the oils have been thoroughly mixed, the quantity of water being determined by succes-

sive trials of small samples. The mixing may be done in an open barrel, which is large enough for all of the formulas except No. 29 and No. 34. Probably a larger tank, as of 60 or 65 gallons, would be a little more convenient with less danger of loss of material. As mentioned, the ingredients blend a little more easily at room or summer temperature than at freezing temperature, but cold weather is no obstacle. A more vigorous agitation is needed at a low temperature than at a more moderate, but the mixture seems possible so long as the oils will run. A cheap device for a stirrer is a small board, about 15 or 18 inches long and 5 or 6 inches wide, attached to a handle, just like a rake. The stirring is best effected by thrusting the dasher up and down, as in a churn."

The formula which was found by the entomologist to give the best result is:

Soap solution,	9 gallons
Paraffine oil,	40 gallons
Resin oil,	6 gallons
Water—as required by test,	(1¼ gallons)

Cost without added water: 16.4 cents per gallon; with water added 15.4 cents per gallon.

In the formula presented by the entomologist it was found that 1¼ gallons of water were required to make the mixture soluble. Nine gallons of water were added to each gallon of the miscible oil in the mixture as applied, making the cost of each spray gallon about 1½ cents.

" 'Paraffine' oil is a trade name for lubricating or machine oil. It is a petroleum product, consisting of the heavier fractions of the crude oil. It is not volatile at the ordinary temperature, and hence would remain indefinitely on the tree if not removed mechanically as by rain. This is, undoubtedly, a most important quality.

"*Resin oil* is a product distilled from resin, of which it forms about 85 per cent. It is thick and viscid at ordinary temperatures, much resembling molasses in consistency. For our purpose it has an extraordinary value in its property of facilitating the making of emulsions with crude oil and paraffine oil. Emulsions of these

latter oils without resin oil are difficult to make. That with crude oil in the absence of resin oil required a large amount of kerosene to be added and requires some ammonia, or at least it is improved by the addition of ammonia; while paraffine oil offers still greater difficulties. But with the use of resin oil these heavy oils are as easy to emulsify as kerosene. This we may accept as a fact without any attempt at explanation, for indeed there is very little in connection with emulsions that can be explained in the present state of our knowledge. Resin itself fulfills much the same office as resin oil, and may be used instead of it; the latter is much the more convenient, however, and nearly as cheap. There is great probability that the resin oil is itself a valuable insecticide, acting mechanically as a suffocating varnish, for varnish making is one of the principle uses of resin and resin oil. It is important to note that in making miscible oils the proportion of resin oil allows less variation than that of any other ingredient; a trifle too much or too little often prevents the emulsion."

The carbolic acid should be "Liquid Crude, 100 per cent. straw color," and this strength and quality should be insisted on. The Barrett Manufacturing Company, of Philadelphia, are mentioned by Mr. Penny, in his Bulletin as proper sources of supply.

The caustic potash should be defined as "*ground* caustic potash 90–92 per cent." and may be obtained from the General Chemical Company, the Bourse, Philadelphia. This potash should be excluded from the air; but in an ordinary covered tin can it may be kept indefinitely.

Prepared as above described the miscible oil ready to use costs less than half as much as the commercial product, excluding the cost of labor. To those who may desire to experiment with preparing it I would emphasize the suggestions made by Mr. Penny as to proper materials and accurate measurements. Improper materials and careless handling will result in failure every time. Rule of thumb methods will not answer.

Another point to which Mr. Penny calls attention is the necessity of thoroughly stirring up and mixing the prepared miscible oil before using it in the spray pump. There is always a chance of a partial separation of some of the materials which can be readily recombined by stirring.

Carbolic Acid.

In the Report for 1906, I gave rather briefly some account of what we had been able to learn concerning this material as a scale-killer when applied in a band on the trunks of the trees. Persistent reports of good effects during the winter of 1906–07, although vague in character, and very positive assertions of faith in the material which were likely to induce a considerable use of it, made it advisable that we should learn more definitely what had been done.

The centre of the Flemington section' faith in the acid, seemed to rest in Mr. Amos Thatcher, of that town, and to his courtesy I owe the opportunity of seeing a number of orchards in his vicinity and of becoming familiar in general with conditions between Flemington and Cherryville. Three visits were made and in four orchards it was possible to note the effects of the material.

Mr. Thatcher has a peach orchard which became so very scaly that it seemed as if it were doomed, no treatment of any kind having been made. It was dehorned in 1905, painted with a banding of carbolic acid 25–30 per cent. strength and made a good growth, free from scale in 1906. In March or April, 1907, the trees were again banded with the acid 50–60 per cent. strength much more liberally applied, and in some cases painted on the branches as well.

When I first saw this orchard in the early days of July, I found all the old wood covered by thick, hard, rough bark, utterly unfit to maintain scale and the new shoots were fresh, vigorous and clean. Not more than enough scale to swear by was found and none that was reproducing. The trees are well looked after, culturally.

There is, in addition, an apple orchard of considerable extent which has been scaly for years, and which became so scaly in 1905 that much of the fruit on some trees was absolutely unusable. The orchard was in grass, which was cut for hay, and had not been cultivated for some years. It was not sod-bound however, and the trees were in general good condition. This orchard was treated much like the peach orchard. It had a banding of the weak acid in the spring of 1906, and a much more liberal applica-

tion of the stronger material in the spring of 1907. At the time I first saw it there was plenty of living scale on the trees, but there were few cases of what might be considered a dangerous infestation. There were some pear trees also, which do not require separate consideration, since the general facts concerning them were the same. Mr. Thatcher states that the trees were in much better condition in 1906 than they were in 1905, and that the fruit was very little infested—practically none that was unusable. As to general condition that might be said to be very good. Scale breeding had just started, a very few larvæ being noticed; but it could not yet be determined how general such breeding would be later.

A peach orchard between Flemington and Cherryville had been banded with acid, but had also been treated with lime and sulphur, and had a record of lime and sulphur treatment for some years. There was very little scale in this orchard, but a horrible infestation of peach curl and quite a bit of yellows. As a test of the value of the acid this could not be of avail; but an apple orchard belonging to the same owner was in a different case. This had been sprayed with lime and sulphur for some years and had nevertheless become steadily worse, until many trees had died and were taken out. More of them were partly dead, and yet more looked as though they had very little interest in life remaining. The orchard was in sod, and had been for some years. Besides scale there was blight and about all the diseases that are usually found in an apple orchard. Some of the dead trees should not be charged to scale at all, and in others it was only one of a number of factors.

Instead of lime and sulphur the orchard received this spring (1907) a broad banding of carbolic acid. Breeding had just begun and there was already a liberal sprinkling of young on some of the trees.

One other peach orhcard was found which offered a fair test of the acid treatment without complications. It consisted of several hundred trees that had never been treated, had just come into bearing, were very scaly and had been banded with acid in the spring. The bands were not very broad and the application had not been very liberal; but every tree had a complete band

approaching one foot in width. Peach curl was very bad in this orchard, and there were many trees with the yellows. No breeding was as yet in progress.

None of the other orchards visited gave any help in this acid problem; but from a number of treated trees I cut sections of bark including painted areas, areas from points above and below and twigs and shoots from treated areas—all these for chemical analysis.

The acid used by Mr. Thatcher and supplied by him to the other users came from the Barrett Manufacturing Company of Philadelphia, and to them I applied for information as to just what was sold to Mr. Thatcher. In reply they state that "The ordinary crude carbolic acid consists of a creosote oil from coal tar, containing a specified quantity of cresol. The party you mention has been buying two grades—the 25–30 per cent. at 20 cents per gallon; and the 50–60 per cent. at 26 cents per gallon, f. o. b., Philadelphia. We understand that this material is used on the bark of trees for destroying the San José Scale. We have endeavored to get more details about this, and are told that some users have found it injured the trees; others that it was beneficial. If you can give us any information we would be very much pleased to receive it. The crude acid mentioned above cannot be diluted with water."

For experimental purposes, the Company was good enough to send a barrel of the 50–60 per cent. material to Mr. Thatcher for use under my direction.

Attention should be called here to the statement that the acid is insoluble in water, and that proved to be the case on experiment. It seems to involve the idea that the sap of the tree contains some solvent of the acid that takes it up and carries it into the circulation.

The cuttings made as above mentioned were turned over to Mr. Charles S. Cathcart, the chemist of the Station for analysis, and some of the thick apple bark was split so as to separate the hard outer layers on which the acid was applied from the green and sappy inner layers in which the circulation was active. There was no difficulty in getting the acid out of the painted portions—

in fact it was present in such quantity as to raise a question whether all that was put on was not actually just where it was put. All the rest of the tests were negative. In the case of the split bark, a small quantity was obtained, which was not unexpected, because the acid stain was noticeable at a few points where it had penetrated almost the entire thickness of the bark. So far as these tests indicate, there is no appearance of the acid in the plant tissue beyond the point at which it was put on.

Some of the acid received by Mr. Thatcher was sent to me and was the material used in painting the nursery apples elsewhere reported upon. To test whether the material might be carried into the ground and get into the circulation through the roots, Mr. Thatcher applied to the surface under and around a natural apple tree three gallons of acid through a sprinkling pot, covering a surface equal to the spread of the branches. The work was done July 19th, after a heavy shower, and it was followed during the night by other showers. The tree was very scaly, had not been treated in 1906, but was painted with the others in 1907. This application killed all the vegetation beneath the tree and no new grass came up again during the season.

A Ben Davis apple, which had been acid banded in 1906, and again in 1907, received an application of 2½ gallons of acid beneath it under the same conditions and at the same time as the other. The apples were no good last year, but this spring (1907) there was only a moderate infestation.

Another Ben Davis, much like the preceding, received two gallons of the acid on the surface beneath it, and this like the preceding killed all vegetation that it touched.

A large Bartlett Pear, acid treated in 1906 and 1907 had an application of 1½ gallons on the surface beneath it. It is a tree only moderately infested now; but on which two years ago the infestation was very severe.

Finally, to test for injury, a Bottle Greening, about 10 inches in diameter, was painted near the butt, with as much acid as it would take up. This had also been treated two years and was yet very scaly.

A large part of the remaining material was distributed by Mr.

Thatcher to neighbors who wished to use it, and were willing to report upon results later.

I went over part of this area again in August to note progress, and finally, on September 21st, to determine results.

The natural apple tree was so much injured by the scale that it is probably doomed. Neither the banding of early spring nor the application of the material to the soil had caused any apparent injury to the tree. Nothing appeared in its condition that was not fully accounted for by the scale infestation, which was very bad. Larvæ and recent sets were present in great numbers.

The two Ben Davis apples receiving respectively 2½ and 2 gallons seemed to be neither better nor worse for the acid treatment. The trees were very badly infested, and there was plenty of living scale, larvæ and recent sets on fruits as well as on the trees themselves. Yet Mr. Thatcher assures me that the trees are in better condition than they were in 1905.

The Bartlett Pear tree was in a very decent condition. There was no fruit, but such as had been taken off had been practically clean. There was plenty of scale on the tree, yet not enough to cause apprehension of harm to it. The fruit on this tree I am told was very badly infested in 1905.

The Bottle Greening treated to a soaking band was still alive, but very scaly and it looked badly. The acid had soaked completely through the bark, had penetrated the sap layer, and the entire bark was dead, completely or nearly so around the trunk. It demonstrates that an excessive application will kill even an old tree and that the acid kills as far as it penetrates. This same feature was apparent on a number of other trees, although on none of them was there anything like a girdling. Nevertheless, so far as the acid penetrates obviously, it kills; that was the record everywhere. There were many trees however in which there was no appearance of discoloration below the surface layer, and where there was no sign of injury of any kind.

Taking the apple and pear orchard as a whole it was not in a bad condition. On some trees the fruit was almost clean; on others it was badly infested; on none of them was it unsaleable. Red apples appeared to be on the whole in worse condition than green apples, and in all cases the orchard was said by Mr.

Thatcher to be in much better condition than in 1905. The pear trees were in about the same case as the apples, and whilst living scale in all stages could be found on all of them, the infestation was not bad on any. That the pear trees had been much worse infested in the past their present condition showed.

In the dehorned peach orchard conditions were excellent. The new growth was vigorous, of good color and clean. There had been only a small crop, most of which was off; what remained was very fine in size, color and flavor. On some trees not a scale could be found, and this was generally the case where the cutting back had been severe and where all the branches had been cut. On some trees some old branches had been allowed to remain, and on some of these the scale has made a fresh start on the new wood; but in all cases there was only a little. On only a few trees on which considerable old wood was allowed to remain was there any serious present infestation and these trees were marked to be taken out or severely cut.

As a whole this orchard is in such condition that it might safely be allowed to go another year without any treatment, and would even mature a crop in 1909 without the loss of any trees.

The peach orchard between Flemington and Cherryville, which had been banded with acid and also sprayed with lime and sulphur was found to be in very nice and clean condition. There had been a very fair crop of fruit and while there was some scale scattered throughout the orchard, there was nothing that endangered any of the trees for this year, and most of them might be considered safe for a year to come.

The apple orchard belonging to the same owner was in quite a different case. The substitution of the acid for the lime had not checked the development of scale in the least and trees that were looking fairly in July were now in a hopeless condition. On other trees—notably Baldwins—the fruit was so badly infested as to be unsaleable. There was not a particle of evidence that the slightest benefit had been derived from the acid. Here also I found that in many cases the acid had penetrated deeply into the bark, and that some trees were partially girdled.

The one peach orchard which had been banded with acid only and had no other treatment of any kind was now in a horribly

scaly condition. Some of the trees were yellow with crawling larvæ or white with recent sets. So bad were conditions indeed, that I advised the owner that if he did not take immediate measures of some kind his trees would not survive the winter. The infestation was not equally bad throughout the orchard, and some trees would probably stand another season; but as a whole the trees were just about as scaly as they could be and live the season out. This is the only case of infested trees where only acid was relied upon, and it has failed here, absolutely. It will be claimed that not enough acid was used, and there is no doubt that the quantity applied was small; but the failure was so uniform and absolute that it is a distinct question whether even double the dose would have been more effective. These trees are of just the age when the scale is hardest on them—*i. e.,* ready to bear the first heavy crop; and if they are not absolutely destroyed by scale next year, will have the bark on all the old wood in about the condition that Mr. Thatcher's trees were in when they were cut back.

The difference in condition between this orchard and the Thatcher orchard is so great that it at once raises the question whether there was not some factor in the one case that was not present in the other and which was responsible for the difference. My explanation of the matter is that the Thatcher orchard became infested more slowly. It was older when the scale became serious, had already born quite well and the wood and bark were altogether more mature. The bark on trunks and all the old wood toughened and became cracked, rough and scaly, and so hard and lifeless that it furnished nothing for the insects if they actually succeeded in setting on it. When Mr. Thatcher cut back, he cut off practically all the live scale on the tree, and what little he left of the old wood was not much infested and not much suited to propagate scale rapidly. There is every probability that had he not applied any acid at all, his trees would be in no worse condition than they are. But there is not, unfortunately, a single untreated tree that might serve as a check.

On August 7th, Mr. Dickerson drove from Lebanon to New Germantown, visiting orchards to determine the effects of whatever treatment had been made. At Bissell he found quite a

number of trees treated with carbolic acid; but most of them had also been treated with either oil or lime and sulphur as well, so that as tests of either material they were useless. He did find some apple trees however that had been treated with acid alone, and on all of them scale was already obvious on the fruit and active on the trees. He saw these trees again in late September and it was then obvious that absolutely no good had resulted from the application. One lot of 6 peach trees in an orchard otherwise treated received only the acid, and these looked poorer than any of the other trees.

At New Germantown spraying was general, "Scalecide" and lime and sulphur both being in use. Some carbolic acid has been used, but in almost all cases was not alone relied upon; it was put as an additional guardian on trees otherwise treated. Some old apple trees had been painted, however, and these had had no other treatment, yet were in much better condition than they were two years ago. The owners believe the acid responsible for the improvement. It was pointed out by others, however, that many other old apples in the vicinity which were very scaly three years ago, and apparently dying, had taken a new start without any treatment whatever, and these also Mr. Dickerson found to be now relatively free from infestation.

Near Lebanon one peach orchard of five thousand trees was found in which 60 trees were treated with carbolic acid in addition to the "Scalecide" treatment which all received. These acid banded trees had been decidedly injured; they were stunted and unhealthy in appearance and altogether much poorer than the rest of the orchard.

August 22d, was spent at Pattenburg and vicinity by Mr. Dickerson, and this vicinity seems to be the stronghold of the acid faith.

The first orchard visited was of large, bearing apple trees. It was treated before the trees started by painting a band two or three feet wide about the trunk, first scraping to remove loose bark. On some of the trees a few limbs during the last year or so have been killed by the scale; but on the whole the trees had a very good color, and some were bearing considerable fruit. Some—Northern Spy, Baldwin, Crab, etc.—showed plenty of live scale

on apples, leaves and twigs. Some trees appear never to have been scaly to any extent, and of course they are in good condition now.

A second, somewhat smaller orchard of the same age, belonging to the same owner, and treated in the same manner, was found to be practically clean. There were only three trees found showing any amount of scale, and there was no indication that the trees now clean had ever been infested.

A third place had a mixed lot of trees—plum, pear, apple, etc. These had been treated for two years, with carbolic acid, in the spring, a band about three feet wide being painted around the trunk. Of the plums one row of Abundance trees was left. These trees, the owner said, were very scaly a year or so ago. Now they show only a small amount of scale on the new growth. A couple of rows of pear trees, more or less scaly a year or so ago, were now in much the same condition as the plum, and showed only a small amount of scale on the new growth. A large "early" apple tree, treated in the same way, showed a great amount of scale on some of the lower limbs.

The fourth place was in town, and the treated trees were around the house—old plum and pear trees. They had been treated by pouring about a quart of the acid in the crotch of the trees and letting it run down the trunk. It had not appeared to harm the trees, which were yet scaly, though not bad. There was scale on the pear fruit, but last year it was said the fruit was so badly infested as to be unusable.

The fifth orchard was bearing peach, and this had been banded with acid and sprayed with a mechanical mixture of oil and water. The result was good. Some apple trees, fifteen years old, had been painted with the acid only, a band a foot or two wide being put on in early spring. These trees showed a large amount of infestation.

A sixth orchard was not visited, but the owner was seen in town. He said he had banded his trees with acid in spring, and they still had plenty of scale; but he believed they would show up better next year.

A seventh orchard was visited, but contained no acid-treated trees.

It should be noted that both of Mr. Dickerson's trips were made before the heavy broods of the season appeared, and that what was only a slight or moderate infestation in August might easily be a serious matter in September.

Altogether this account presents the best possible statement in behalf of the acid. In my account of the scale conditions, I have called attention to the fact that conditions this year did not favor the scale at all, and that, even where no treatments at all had been made, great improvements were noted. So far as the older apples were concerned, there is not a particle of evidence in any case that any real improvement had been caused by the acid. There is very definite evidence that it is quite possible to kill apple trees, ten inches in diameter, by an overdose, and that young apples cannot be safely treated at all.

As for peach, there are only two large treated orchards known to me. In one case the acid failed absolutely, in the other the apparent success may not be due to the acid only, or at all. Only a few plum trees have been treated, and all of these have improved; but the trees were too few in number to serve as bases for definite conclusions. So the number of pears treated is too small to warrant conclusions. In no instance was a tree entirely freed from scale, and whether in a more normal season the surviving remnant would not have become more obvious is a question.

At all events I would not advise anyone to use the acid as a sole dependence in a badly infested orchard. I do advise, as an experiment, in an orchard where trees are so slightly infested as to be in no danger, that from the general treatment a row be left untreated, and another treated with the acid. The results of a number of such tests will soon furnish conclusive evidence as to the value of the material. Paint a band two feet wide, and put on as much as is readily absorbed by the surface; when it begins to run off, stop.

Avenarius Carbolineum.

This material was brought to my notice by the American agents of the German manufacturers, with the statement that it had been successfully employed against a variety of insects by painting the

trunks, which seemed to render the tree proof against insect attack, caused it to grow more vigorously, etc. In other words, the claims made for the carbolic acid were duplicated; and yet not exactly, for here it was recommended to paint trunks and branches, and it was rather as a destroyer of cankers and insects, and as a healer, that it was proposed. The material was received too late to permit of any real tests, and only four small apple trees were treated as described in the records of the nursery trees. The results were altogether negative, but not conclusive.

It seems, however, that this is not as I was at first inclined to consider it, an attempt to make capital out of a few cases of apparent results, but that Carbolineum has been rather carefully tested for a series of years in Germany, and notably at the Royal Institute for wine, fruit and garden culture at Geisenheim a. Rh., an institution that I visited in 1900, and which ranks as one of the best of the German Experiment Stations. In their reports for 1905 and 1906 this material is favorably referred to, and was used as a destructive agent against the Pear Scale, which is almost as dangerous locally as the San José Scale is with us. But there is no pretence that the material acts through the sap; it is simply a very effective contact poison, and kills exactly as do the petroleum oils.

Applied undiluted on apple trees of various kinds in April so as to cover completely, no harm had been done a year afterward. Painted on canker sores and on sore and cracked areas it checked the spread of the disease, caused the formation of new bark, and seemed to destroy the morbific organisms.

Applied on pear trees it destroyed the scales infesting them, and induced a vigorous healthy growth. Pictures illustrating treated and untreated trees show a remarkable difference in favor of those that were treated. Just how this result was produced is not stated, but it is strictly analogous to the results noted in some cases from an application of crude petroleum on similar trees, or from the application of lime and sulphur on peach trees. It seems to be a fungicide as well as insecticide, and merits further experimental use.

The material is one of the products of coal-tar distillation, and contains a large percentage of phenol; it is a close relation of car-

bolic acid in other words. It is not directly miscible with water. but may be rendered so by using an alkali, *e. g.*, soda, or making an emulsion with soap suds. As to its effective strength nothing is known save that undiluted it is fatal to almost all kinds of insect life. It is equally fatal to growing plant life, and must not be used on foliage of any kind.

Nothing can be done at present except to call attention to the material as one meriting further trial.

Arsenate of Lead.

During the past year a number of new brands of this material have been placed on the market by chemical companies like the Grasselli Company, and paint-makers like the Sherwin-Williams Company. Analyses of several of the brands used in New Jersey were published in the report for 1906. None of the new brands received were analyzed at this Station, but Mr. John P. Street, who made the analyses for me last year continued the same kind of work at the Connecticut Station, and found in all the brands examined practically the same range of percentage of actual arsenic reported by me, *i. e.*, from 11% to 21%.

The only experiments made during the season of 1907 were to determine the effect on foliage of the Vreeland arsenate of lead, which contains the largest percentage of arsenious oxid, and is made by a method entirely different from the other brands. It was used on all the ordinary orchard trees, peach, apples, pear, cherry, quince, and on Japanese walnut, at rates far in excess of requirements and without causing even the slightest injury in any case.

As this material costs no more than the other brands, and contains from 6% to 10% more actual arsenious oxid, this would seem to be the cheapest and most effective material to use. Two and one-half pounds of this will equal one pound of Paris green, and three pounds in 100 gallons of water will do the work for which four to five pounds of the other brands are required.

As a general rule five pounds of arsenate of lead should be used in 100 gallons of water until manufacturers print on their

labels the actual percentage of arsenious oxid contained in their material. The advantages may be again stated as harmless to foliage of all kinds at any strength, great adhesiveness or lasting qualities, remains in suspension for a longer time than any other arsenical insecticide preparation.

Arsenate of Iron.

From Dr. Fred. P. Dewey of Washington, D. C., I received about 100 pounds of this material, said to be a by-product in ore preparation, and to contain about 45% of arsenious oxid or arsenic. No analysis of the material was made at the Station, but, as I know Dr. Dewey as a reliable chemist, I accepted his statement of the composition of the material and that it contained very little, if any, water-soluble arsenic.

Trial of the material was made by Mr. Dickerson early in July on some elm trees infested by larvæ of the elm-leaf beetle, on the basis of an equivalent of one pound of Paris green in 100 gallons of water. Rating the arsenic in Paris green at 55%, it required 1¼ pounds of the arsenate of iron to 100 gallons of water, and at that rate it was applied July 17th, weather warm and fair. The solution when mixed was green in color, and the material remained in suspension fairly well only. Some sediment remained in the spraying tank despite agitation during application.

There was a heavy rain on the afternoon of July 18th, and a lighter precipitation on the 20th, so that on the 22d there was little trace of the material remaining. There was no trace of injury to the foliage at that time, but the larvæ had disappeared. The conclusion was that the material was effective against the insects and harmless to foliage at the strength employed. No injury developed later on the sprayed foliage.

A second application was made of this material in competition with arsenate of lead against the army worm on the College Farm in July. Details of this application are given in the account of the appearance of this insect on the College Farm, and only the conclusion need be referred to here. No harm was caused to foliage and, as against the caterpillars, it was satis-

factorily effective—quite as much so as the arsenate of lead. It was intended to use the material further on field crops on the College Farm, but opportunity did not serve.

From what has been done, it appears that arsenate of iron is worthy a careful test, and promises well. It is not yet regularly on the market and there is no price for it. Further experiments may be postponed until there is a commercial preparation in hand, or offered to the agricultural public.

Arsenate of Lime.

This is a second material received from Dr. Dewey, and was said to contain 48 per cent. of actual arsenic, no appreciable portion of it water soluble.

This was tried in competition with the arsenate of iron at the same time and on the same basis; requiring 1⅛ pounds to 100 gallons to equal 1 pound of Paris green.

It was white in the solution, very fine, and remained in suspension very well. On the examination made on July 22d there was no appearance of injury to the foliage; but as a number of larvæ yet remained on the leaves the effect was not satisfactory. It was not to be compared in efficiency with the iron.

Combinations of arsenic and lime are well known and very easily prepared by the farmer himself. Therefore, any such material as this sent in for trial, must be offered very cheaply to make it worth while testing further. It is bound to be effective in proportion to the amount of actual arsenic contained, and safe in proportion to the completeness of combination between arsenic and lime.

Arsenate of Barium.

This is the third of the materials sent in for trial by Dr. Dewey, and was said to contain only 30 per cent. of arsenic. Tested in comparison with the arsenates of iron and lime, and at the same time; it required 1 4-5 pounds in 100 gallons of water to bring it up to the same strength as the others.

It was white in solution, coarser than either of the others and remained in suspension very poorly. It was impossible to spray without a sediment.

On July 22d the treated foliage was spotted and showed undoubted marks of injury. This, and the fact that it had harmed the larvæ less than it did the leaves discouraged further trial.

EXPLANATION OF PLATES AND FIGURES.

PLATE FIGURE 1.

Placing tarred paper disks on cabbage plants. From an original photo.

PLATE FIGURE 2.

The short unbroken row of cabbages shows the effect of the tarred disks; the other rows were otherwise treated. From an original photo.

PLATE FIGURE 3.

Work of cabbage maggot in wild radish plants in October. From an original photo.

FIGURE 4.

A combined furnace and kettle, made by the Philadelphia Farmers' Supply Company. Electrotype by courtesy of the company.

REPORT OF THE MOSQUITO WORK IN 1907.

Report of the Mosquito Work in 1907.

BY JOHN B. SMITH, SC. D.

The work of the year extending from November 1st, 1906, to October 31st, 1907, was carried on under Chapter 134 of the Laws of 1906, which went into effect on November 1st, 1906, and reads as follows:

AN ACT to provide for locating and abolishing mosquito-breeding salt-marsh areas within the State, for assistance in dealing with certain inland breeding places, and appropriating money to carry its provisions into effect.

BE IT ENACTED *by the Senate and General Assembly of the State of New Jersey:*

I. It shall be the duty of the director of the State Experiment Station, by himself or through an executive officer to be appointed by him to carry out the provisions of this act, to survey or cause to be surveyed all the salt-marsh areas within the State, in such order as he may deem desirable, and to such extent as he may deem necessary, and he shall prepare or cause to be prepared a map of each section as surveyed, and shall indicate thereon all the mosquito-breeding places found on every such area, together with a memorandum of the method to be adopted in dealing with such mosquito-breeding places, and the probable cost of abolishing the same.

2. It shall be the further duty of said director, in the manner above described, to survey, at the request of the board of health of any city, town, township, borough or village within the State, to such extent as may be necessary, any fresh-water swamp or other territory suspected of breeding malarial or other mos-

quitoes, within the jurisdiction of such board, and he shall prepare a map of such suspected area, locating upon it such mosquito-breeding places as may be discovered, and shall report upon the same as hereinafter provided in section eight of this act. Requests as hereinbefore provided for in this section may be made by any board of health within the State, upon its own motion, and must be made upon the petition, in writing, of ten or more freeholders residing within the jurisdiction of any such board.

3. Whenever, in the course of a survey made as prescribed in section one of this act, it is found that within the limits of any city, town, borough or village there exist points or places where salt-marsh mosquitoes breed, it shall be the duty of the director aforesaid, through his executive officer, to notify, in writing, by personal service upon some officer, or member thereof, the board of health within whose jurisdiction such breeding points or places occur, of the extent and location of such breeding places, and such notice shall be accompanied by a copy of the map prepared as prescribed in section one, and of the memorandum stating the character of the work to be done and its probable cost, also therein provided for. It shall thereupon become the duty of the said board, within twenty days from the time at which notice is served as aforesaid, to investigate the ownership, so far as ascertainable, of the territory on which the breeding places occur, and to notify the owner or owners of such lands, if they can be found or ascertained, in such manner as other notices of such boards are served, of the facts set out in the communication from the director, and of the further fact that, under chapter sixty-eight of the laws of one thousand eight hundred and eighty-seven, as amended in chapter one hundred and nineteen of the laws of one thousand nine hundred and four, any water in which mosquito larvæ breed is a nuisance and subject to abatement as such. Said notice shall further contain an order that the nuisance, consisting of mosquito-breeding pools, be abated within a period to be stated, and which shall not be more than sixty days from the date of said notice, failing which the board would proceed to abate, in accordance with the act and its amendments above cited.

4. In case any owner of salt-marsh lands on which mosquito-breeding places occur and upon whom notice has been served as above set out, fails or neglects to comply with the order of the board within the time limited therein, it shall be the duty of said board to proceed to abate under the powers given in section thirteen and fourteen of the act and its amendments cited in the preceding section, or, in case this is deemed inexpedient, it shall certify to the common council or other governing body of the city, town, township, borough or village the facts that such an order has been made and that it has not been complied with, and it shall request such council or other governing body to provide the money necessary to enable the board to abate such nuisance in the manner provided by law. It shall thereupon become the duty of such governing body to act upon such certificate at its next meeting and to consider the appropriation of the money necessary to abate the nuisance so certified. If it be decided that the municipality has no money available for such purpose, such decision shall be transmitted to the board of health making the certificate, which said board shall thereupon communicate such decision forthwith to the director of the Agricultural Experiment Station or his executive officer.

5. If, in the judgment of the director aforesaid, public interests will be served thereby, he may set aside out of the moneys appropriated by this act such an amount as may be necessary to abate the nuisance found existing and to abolish the mosquito-breeding places found in the municipality which has declared itself without funds available as prescribed in the preceding section. Notice that such an amount has been set aside as above described shall be given to the board of health within whose jurisdiction such mosquito-breeding places are situated, and said board shall thereupon appoint some person designated by said director or his executive officer a special inspector of said board for the sole purpose of acting in its behalf in abating the nuisance found to be existing, and all acts and work done to abate such nuisances and to abolish such breeding places shall be done in the name of and on behalf of such board of health.

6. If in the proceeding taken under section four of this act the common council or other governing body of any municipality

appropriate to the extent of fifty per centum or more of the money required to abate the nuisance and to abolish the mosquito-breeding places within its jurisdiction it shall become the duty of said director of the Agricultural Experiment Station to set aside out of the moneys herein appropriated such sum as may be necessary to complete the work, and in all cases preference shall be given, in the assignment of moneys herein appropriated, to those municipalities that contribute to the work and in order of the percentage which they contribute; those contributing the highest percentage to be in all cases preferred in order.

7. In all cases where a municipality contributes fifty per centum or more of the estimated cost of abolishing the breeding places for salt-marsh mosquitoes within its jurisdiction, the work may be done by the municipality as other work is done under its direction, and the amount set aside as provided in section six may be paid to the treasurer or other disbursing officer of such municipality for use in completing the work; but no payment shall be made to such treasurer or other disbursing officer until the amount appropriated by the municipality has been actually expended, nor until a certificate has been filed by the director or his executive officer stating that the work already done is satisfactory and sufficient to obtain the desired result, and that the arrangements made for its completion are proper and can be carried out for the sum awarded.

8. In all investigations made under section two of this act the report to be made to the board of health requesting the survey shall state what mosquitoes were found in the territory complained of, whether they are local breeders or migrants from other points, and, in the case of migrants, their probable source, whether the territory in question is dangerous or a nuisance because of mosquito breeding, the character of the work necessary to abate such nuisance and abolish the breeding places, and the probable cost of the work. Said board of health must then proceed to abolish the breeding places found under the general powers of such boards, but if it shall appear that the necessary cost of the work shall equal or exceed the value of the land without increasing its taxable value, such board may apply to the director aforesaid, who may, if he deems the matter of sufficient

public interest, contribute to the cost of the necessary work, provided that not more than fifty per centum of the amount shall be contributed in any case, and not more than five hundred dollars in any one municipality.

9. All moneys contributed or set aside out of the amount appropriated in this act by the director of the Agricultural Experiment Station in accordance with its provisions shall be paid out by the Comptroller of the State upon the certificate of said director that all the conditions and requirements of this act have been complied with, and in the case provided for in section five payments shall be made to the contractor upon a statement by the person in charge of the work, as therein prescribed, attested by said director, showing the amount due and that the work has been completed in accordance with the specifications of his contract.

10. For the purpose of carrying into effect the provisions of this act, the said director of the State Agricultural Experiment Station shall have power to expend such amount of money, annually, as may be appropriated by the Legislature; *provided,* that the aggregate sum appropriated for the purposes of this act shall not exceed three hundred and fifty thousand dollars. The Comptroller of the State shall draw his warrant in payment of all bills approved by the director of the State Experiment Station, and the Treasurer of the State shall pay all warrants so drawn to the extent of the amount appropriated by the Legislature.

11. This act shall take effect November first, one thousand nine hundred and six.

Approved April 20, 1906.

Pursuant to the provisions of section 1 of said act the writer was appointed executive officer by Dr. Edward B. Voorhees, Director of State Experiment Station, for the purpose of carrying out the requirements of said act, and work was at once begun under its provisions.

In the regular appropriation bill, taking effect November 1st, 1906, the Legislature had made available for the purpose of this work the sum of $13,500. In the supplemental bill which went into effect May 21st, 1907, the further sum of $10,000 was made

available, making a total of $23,000 to be applied to the work during the fiscal year.

In planning out the work to be done, regard was had primarily to two points: Those communities which had already expended considerable sums on their own behalf or were ready to contribute materially to the work, were entitled to be first considered: Those areas of salt marsh whose mosquito output affected the largest population should be dealt with as soon as possible. As it happened there was no conflict between these two purposes, because Newark and Elizabeth, which had already made large expenditures, were also large centres of population, and Jersey City, which forms part of the same general centre, provided sufficient funds for all the work in its own territory.

Surveys of the Elizabeth and Jersey City marshes had been already made under a previous law, and formal notices were served upon the boards of health of both cities soon after the new law went into effect. A copy of the notice served upon the Elizabeth board of health will illustrate the form that has been uniformly followed in all subsequent proceedings

"GENTLEMEN—Please take notice, that in the course of a survey, made in accordance with section 1 of Chapter 134 of the Laws of 1906, the following salt marsh mosquito breeding areas were found within the limits of the city of Elizabeth, and within your jurisdiction, as shown in the maps hereto attached. These areas are located on said maps by lettered sections, more particularly described as follows:

"*Section A* is a triangular area, bounded on the north by a spur of the Newark branch of the Central Railroad of New Jersey, which runs through Great island, on the east by the said Newark branch of the said railroad, and on the west by Woodruff creek and Great ditch.

"*Section B* is a long, narrow area lying between Woodruff creek and Great ditch on the east, the highland on the west, the Newark branch of said Central railroad on the south, and the spur of this railroad on the north.

"*Section C* is an arrow-shaped area lying between Woodruff creek and a division of this creek on the east, the highland on the west, and said spur of the Newark branch of the Central railroad on the south.

"*Section D* is an irregular stretch of land, bounded by Woodruff creek on the north and west, by the Newark branch of said Central railroad on the east, and by a spur of said railroad on the south.

"*Section E* is the area bounded by Bound creek on the east, the highland and a branch of Woodruff creek on the west, and Woodruff creek on the south.

"*Section F* is the small triangular area bounded on the north by a wagon road extending into the marsh, on the east and south by Oyster creek, and on the west by said Newark branch of the Central railroad.

"*Section G* is a large area bounded by Bound creek on the north, by Newark bay on the east, by the Newark branch of said Central railroad on the west, and by Oyster creek and said wagon road on the south.

"*Section H* is a triangular area between Oyster creek on the north and west, Newark bay on the east, and the area already drained on the south.

"*Section I* is an area bounded on the south by the Elizabeth river, on the west by the New York and Long Branch railroad, and on the north by the Highland: this latter area being part of that already drained along the Elizabeth river, and this needs only a few ditches to perfect the drainage.

"You are further notified that the character of the work to be done is the placing of deep ditches of a width shown on said maps at such intervals as may be necessary to drain off the surface water, supplemented by filling the deeper holes with the sods taken from the ditches. That the total area to be drained is approximately 2,210 acres, and that the probable cost of the work required to drain the entire areas above mentioned, so as to dispose of all the mosquito breeding, is the sum of five thousand three hundred dollars ($5,300).

"This notice is served upon your body pursuant to the requirements of section 3 of said Chapter 134 of the Laws of 1906 aforesaid."

The descriptive portion is, of course, different in each case; but all the other features are identical, and in every case a printed copy of the law and a blue print of the survey and ditching plan accompanied the notice.

The notices to owners served by the various boards of health differed somewhat in form and were usually drawn by the Coun-

sel of such boards. That served by Jersey City is shown on figure 1, made from one of the posted notices on the marsh.

The last paragraph of this notice was usually omitted in municipalities that had not made any appropriation for the work, and the description of the location of the land varied in accordance with local requirements. The essential features, however, the notice that mosquito breeding places existed, that they were nuisances, the order to abate and the notice that in case of failure the work would be done by the Board were the same in all cases.

It proved unexpectedly difficult in some instances to ascertain the names of the owner of marsh lands, and so notices were posted on the marsh itself. In one case the lands were not even listed for taxation and so, in order to reach all parties, the notices were published in the local newspaper as well as posted.

At the expiration of the time limit, notice was usually given to the writer, formally or informally, of the fact that nothing had been done, and the local municipal authorities were formally requested to contribute or provide for the work to be done.

The cities of Jersey City, Rahway and Long Branch paid for all the work required within their own limits. The City of Elizabeth contributed the sum of $1,000 toward the work done this year, but had in previous years expended sums making an equivalent of about 50 per cent. of the entire cost of the work done within its own limits.

After all the preliminary requirements of the law had been complied with, and the Director had approved by setting aside a sufficient sum to do the necessary work, specifications were drawn, and bids were asked for from contractors fitted to do marsh work. In the Jersey City and Long Branch work bids were advertised for, and in Jersey City the specifications and maps were examined by a number of contractors for other city work. As soon as they learned that special tools and apparatus was needed, and that they would come into competition with special machinery, they refused to enter the contest, and practically all contests narrowed down to

Mr. Jesse P. Manahan, Monmouth Beach, N. J.
Mr. Eugene Winship, Staten Island, N. Y.
Mr. Edwin M. Skinner, Staten Island, N. Y.

BOARD OF HEALTH

JERSEY CITY, N. J.

SANITARY DEPARTMENT

City Hall,____________________1907

Mr.______________________________

____

Pursuant to an Act of the Legislature entitled, "An Act to provide for locating and abolishing mosquito breeding salt-marsh areas within the State of New Jersey," etc., being Chapter 134. Laws of 1906, approved April twentieth, 1906 and in effect November first 1906, you are hereby notified that certain land by you owned and designated on the city map of Jersey City, N. J., as Plot Block , is a mosquito-breeding salt-marsh and contains pools, in which mosquito larvae breed and which said pools are declared a nuisance and subject to abatement as such, under Chapter 68 of the Laws of 1887, as amended in Chapter 119 of the Laws of 1904.

You are further notified to abate or cause to be abated the said nuisance, consisting of mosquito-breeding pools, within a period of ten days from the date of this notice, failing which this board will proceed to abate said nuisance by ditching said plot or plots, thereby subjecting said pools to tidal ebb and flow.

Money appropriated for the purpose, under the provisions of the law first above cited, will be used to defray the cost of the work.

Respectfully,

HENRY SMELLIE,

Health Officer.

Figure I.

Notice to abate as posted on Jersey City marsh.

Figure II.
The Skinner ditching spade on the Woodbridge marsh.

Mr. Harry Wolfe, New York city, N. Y.
The Monmouth Contracting Co., Atlantic Highlands, N. J.
Mr. H. H. Judson, New York city, N. Y.

Mr. Jesse P. Manahan had secured control of the True ditcher, first by hire and afterwards by purchase; was well equipped with bog saws and spades; had the experience of work done on the Shrewsbury and Newark marshes to his credit, and was financially able to carry all the work. Most of the contracts were awarded to him; they were always well performed, and practically within the time limits of the contracts.

Messrs. Winship and Wolfe were at various periods associated with Mr. Skinner, and relied at first upon a ditching machine invented by Mr. Skinner. This machine, as a matter of fact, never got on the marsh for practical work at any period of the fiscal year, and is yet really untried. The Linden contract was originally awarded to Mr. Skinner as the lowest bidder, but he was unable to secure the required bond and it went, therefore, to the next lowest bidder who assumed it at the amount bid by Mr. Skinner. The Woodbridge contract was awarded to Messrs. Skinner and Wolfe as the lowest bidders, and they qualified in due course. They failed to make a start, however, until so late that compliance with their contract became impossible, and, as that date was so late that it would have been impossible to have it finished within the fiscal year by any one else, after consultation with the office of the Attorney-General, the time limit to the contract was waived and they were allowed to go ahead. The work done by this firm is good, and they have in service an excellent spade of special, patented design, figured in this report, which enables them to make a clean, straight ditch which does excellent service. Whether their machine will ever prove practical is another question.

The other bidders, depending upon other tools or hand labor only, soon dropped out, unable to compete with the contractors just mentioned.

The work to be done in Long Beach township was somewhat in the nature of an experiment, and, as the machines here would be of little service, two other contractors were invited to bid:

Mr. Benjamin S. Cox, Beach Haven, N. J.

Mr. John Bell, Haddonfield, N. J.

The character and remuneration to be expected failed to appeal to these gentlemen, and they declined to enter into the competition.

The following copy of specifications, prepared for the Linden township work, is an example of all those used. Each locality offers some little peculiarities that make slight changes imperative, but the essential requirements were in all cases the same.

Specifications for Drainage Work Required on the Salt Marshes in Linden Township.

1. The contractor must undertake for a lump sum to drain, by ditches of such size and depth as may be needed, the salt-marsh area shown on a map prepared by the executive officer of the Director of the State Experiment Station, in accordance with Chapter 134 of the Laws of 1906, and on file in the office of the Board of Health of the Township of Linden, at the Township Clerk's office in the town of Linden. But small, deep holes between the lateral ditches shown on said map, which do not drain with sufficient rapidity, must be filled with material taken from the ditches, and larger pools or holes may be either filled or drained by a sufficient spur ditch into the nearest regular ditch.

2. All ditches are to be 30 inches in depth, except where a greater depth is required on the map already referred to. They shall have smooth sides or walls, and shall be even in course so as to prevent clogging or interruption of flow. They shall be within two inches as wide at bottom as at top, and the bottom shall be level so that the water may not lie dead in pools or pockets at any time, even if to obtain such level it may be necessary in carrying it through an elevation in the marsh to make it deeper than specified for the general course of the ditch.

3. All sods shall be removed at least three (3) feet away from all ditches, to prevent the bank from caving in and the sods from falling back into the ditches.

4. All the ditches marked on said map shall be cut, and shall be of the width and depth marked on said map. The location of such ditches as laid down on said map is approximately correct,

and the length of such ditches, as a whole, is also approximately correct; but where such ditches are drawn between points to be connected they shall be between these points as they are on the marsh, and not as they may be laid down on the maps. But no more than 14,500 feet of cleaning out old ditches and 251,000 feet of new ditches shall be required of the contractor, except such spur or branch ditches as may be needed, as specified under Section 1. Attached hereto is a specific statement of the work required, as measured out on said map.

5. All ditches will be located, lined out, and the widths and depths indicated for the contractor by an inspector appointed for that purpose, who shall have general oversight of the work and shall, whenever requested by the contractor, certify the proportion of work done. Such inspector shall have no authority over the contractor or his employees in his practical carrying out of the contract and digging the ditches, but he shall call the attention of the contractor to any departure from the true meaning of these specifications which may delay or prevent the giving of a certificate for satisfactory work done. In case of any difference between the contractor and the inspector the contractor may appeal to the executive officer appointed under the law cited in the first section, and his decision shall be final.

6. Bidders should satisfy themselves by personal inspection, or in such other way as they may prefer as to the character, extent and location of the proposed work, of the general accuracy of the said map and as to whether the character of the marsh to be drained is such as to permit of the kind of operation by means of which they propose to carry on the work. No claims for compensation other than specified in the contract will be considered, within the limits of the areas to be drained or within the general scheme of drainage as laid down on said map.

7. Contractors must furnish all tools, machinery, material and labor required to do the work in a satisfactory manner, and must agree to complete the work on or before the 1st day of September, 1907. In case the work is not completed on the date mentioned, the contractor may be declared in default and the remainder of the work to be done will then be completed under the direction of the Board of Health of the township of Linden, and the con-

tractor shall be liable for any loss sustained by any difference between the contract price and the price actually paid to complete the work.

8. Payments will be made as follows: When one fourth of the work is satisfactorily completed a certificate to that effect will be given by the inspector, and this may be presented by the contractor to the executive officer who will thereupon prepare such bills and vouchers as are necessary to secure payment to the contractor of one fourth the contract price. When one half of the work is satisfactorily completed a similar certificate will be given and bills to the amount of a second one fourth of the contract price will be prepared in the same way. When three-fourths of the work shall have been completed, one third of the remaining contract price will be certified and paid in the same way, and when the whole of the work shall have been satisfactorily completed and a certificate to that effect is in hand, the whole of the balance will be certified for payment upon the presentation of proof by the contractor that there are no outstanding claims upon him for material or labor or claims for damages caused by the contractor which might be made the subject of a lien upon the land on which the work is done or a charge against the municipality within which it is located; but this is not to apply to any claim for damage alleged to be caused by following out the terms of these specifications.

9. The contractor shall pay to the inspector the sum of $25.00 for each certificate which entitles him to a payment, or a total of $100.00 in all, and this amount should be included in the estimate of the cost of the work to be done.

10. The person or persons to whom the contract shall be awarded will be required to give a bond conditioned for the faithful performance of the contract, in the sum of $1,000.00, with such sureties as shall be satisfactory to the executive officer above mentioned.

11. The right to reject any and all bids is reserved to the executive officer if he shall not consider them satisfactory.

The contracts also, were uniform in tenor throughout, and that for the Linden Township work may serve as an example of all of them.

"This agreement, made this sixth day of July, 1907, between John B. Smith as Executive Officer appointed by the Director of the Agricultural Experiment Station to carry out the provisions of Chapter 134 of the Laws of 1906, acting on behalf of the Board of Health of the Township of Linden, party of the first part, and Jesse P. Manahan of Monmouth Beach, New Jersey, Contractor, party of the second part. Witnesseth—

First: The party of the second part in consideration of the agreements of the party of the first part hereby undertakes and agrees for the sum of three thousand, six hundred and fifty dollars $3,650.00) to ditch, fill and drain so as to free from mosquito breeding pools all that area of salt marsh territory situate, lying and being within the Township of Linden, as laid down on a map now on file in the office of the Board of Health of said Township and in accordance with the specifications for such drainage also on file; said map and specifications, copies of which are hereto annexed, being made part of this contract and evidence of the extent and character of this undertaking and agreement.

Second: The said party of the second part agrees to dig all the ditches as laid down on said map, of the width and depth mentioned on said map and specifications, and as described in paragraph 2 of such specifications. He further agrees to remove all sods as required in paragraph three of such specifications: except as special permission may be given by the party of the first part for long sod strips cut by machine and not needed for filling. He further agrees to conform to the directions of the Inspector to be appointed as set out in said specifications in all points not counter to their true intent and meaning, and he agrees to pay said Inspector the sum of $100.00 for his services

Third: The party of the second part further agrees to complete the entire work laid out on said map and described in said specifications on or before the 1st day of September which will be in the year 1907.

Fourth: And in default or in case of his failure to complete the work above described within the period above limited, said party of the second part hereby agrees to forfeit his right to complete such work under this contract and to receive compensation therefor and agrees that in case of such failure the party of the

first part hereto shall have the right to declare this contract void and of no further effect, and he agrees that such party of the first part shall have the right to complete the work under his own direction, and said party of the second part will hold himself liable for any difference between the amount for which he hereby agrees to do the work and the sum which may be actually paid to complete the work; but such liability shall not exceed the sum of one thousand dollars ($1,000.00).

Fifth: Said party of the second part further agrees to do the work required in this contract in a good and workman-like manner according to the true intent and meaning hereof, and he will hold the party of the first part free and harmless from all claims or liability for material, supplies or labor employed in said work, and from all liability for damages due to his own acts or those of his agents or employes, but not from liability incurred through following out any directions given by the party of the first part or his agents.

Sixth: The party of the first part, in consideration of the above undertakings and agreements, agrees on his part to secure to the party of the second part or his assigns, the just and full sum of three thousand, six hundred and fifty dollars (3,650.00), as prescribed in Chapter 134 of the Laws of 1906 aforesaid, and he agrees to prepare all necessary certificates, vouchers and papers required to procure such payment as follows: The sum of nine hundred and twelve dollars and fifty cents ($912.50), or one-fourth of the contract price upon presentation of a certificate from the Inspector appointed as hereinafter described, that one-fourth of the work is satisfactorily completed; the further sum of nine hundred and twelve dollars and fifty cents ($912.50), making one-half the contract price, upon presentation of a certificate from such Inspector that one-half of the work is satisfactorily completed; the further sum of six hundred and eight dollars and thirty-three cents ($608.33), or one-third of the remainder of the contract price on presentation of a certificate that three-fourths of the work has been satisfactorily completed, and the sum of one thousand, two hundred and sixteen dollars and sixty-seven cents ($1,216.67), completing the contract price upon presentation of a certificate that the work has been fully completed, and proof that

there are no outstanding claims for work, supplies or material of any kind which might be made the subject of a claim against the party of the first part or a lien upon the land upon which the work is done.

Seventh: The party of the first part further agrees to secure the appointment of an inspector, whose duty it shall be to lay out for the party of the second part all the ditches that are to be dug, and to specify their width and depth, subject to the limitations of the specifications. Such inspector shall also point out where filling or spur ditches are needed and shall advise the contractor whenever required to do so; but he shall exercise no authority over the employes of the contractor, nor shall he be required to act as a foreman or to direct the workmen except as already provided. Said inspector shall also certify at any time when requested by the contractor the proportion of work that has been actually and satisfactorily completed.

In witness whereof the parties hereto have hereunto and to a counterpart hereof set their hands the day and year first above written."

The contracts that were made under the supplemental bill were all first submitted to the Attorney-General's office for approval as to form, and then to the Governor for his approval, as required by the terms of the said law. The approved contracts were filed in the office of the Comptroller, and payments were made directly to the contractors, in all cases, upon the certificates given as required in the law under which the work was done.

In the order of time the following work was done under the provisions of the law, for the amounts specified:

Elizabeth (City paid $1,000),	$5,300.00
Jersey City (City paid all),	2,100.00
Linden Township,	3,650.00
Sayreville Township,	525.00
Raritan Township,	3,475.00
Rahway (City paid all),	200.00
Long Beach, south of Beach Haven,	3,100.00
Roosevelt Borough,	1,400.00
Newark addition,	250.00
Woodbridge Township,	2,500.00

Long Branch (City paid all),	180.00
Middletown Township,	200.00
A total of,	$22,880.00
of which the municipalities paid,	3,480.00
and the State,	$19,400.00
at an expense for administration of,	4,100.00
Balancing the appropriation of,	$23,500.00

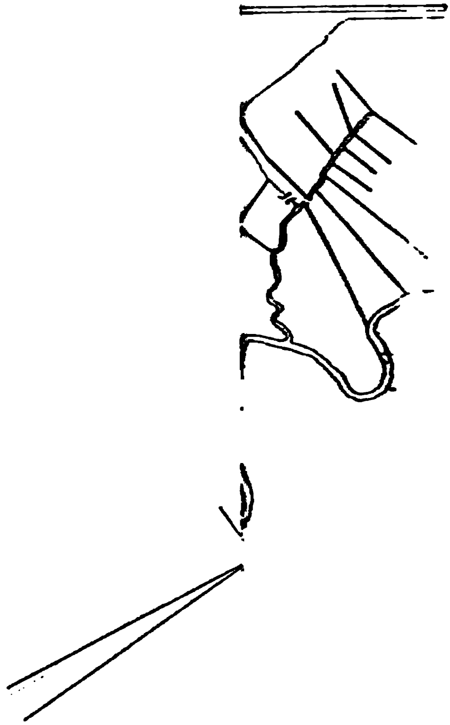
As to the areas embraced in these marshes and the amount of ditching required, the following statement will give information:

	Area in Acres.	Feet of Ditching.
Elizabeth,	2,500	366,000
Jersey City,	640	113,500
Linden Township,	1,936	264,812
Sayreville Township,	538	26,500
Raritan Township,	1,456	168,600
Rahway,	110	10,312
Long Beach Township,	1,472	248,100
Roosevelt Borough,	640	90,100
Newark addition,		66,800
Woodbridge Township,	1,616	145,100
Long Branch,	30	3,000
Middletown Township,	13	2,700
Total,	10,951	1,505,524

Of this ditching 82,522 feet were old, existing channels cleaned and deepened to accord with our requirements; 8,850 feet were 2 feet wide and 3 feet deep; 5,680 feet were 20 inches wide and 30 inches deep, and the balance of 1,408,472 feet is 10 inches wide and approximately 30 inches deep.

The work done in previous years covers 3,500 acres of marsh in the City of Newark, with 360,000 feet of ditches; over 100,000 feet of ditches put in the Elizabeth marshes included in the acreage above given, and about 250,000 feet of ditching on approximately 1,400 acres of marsh area on both sides of the Shrewsbury river

This gives a grand total of 2,215,524 feet of ditches on 15,851 acres of salt marsh; not at all a bad record for work done under adverse conditions against almost constant opposition and under



financial handicaps that prevented the most economical methods of work.

Elizabeth.

In the Report for 1906 will be found a statement of the work done on the Elizabeth marshes up to the end of the season of that year, and also of the contributions made by the city and the State under the preceding laws. The willingness of the city to do all that lay within its ability and the amount of the expenditures already made as well as the large number of inhabitants directly affected, entitled that community to early consideration under the new law. Careful surveys and maps had been made, and as soon as the law went into effect the necessary formal notices were served to gain jurisdiction. In this work the office had the cordial and effective co-operation of the Elizabeth board of health, and especially of its health officer, Mr. Louis J. Richards, to whom special acknowledgements must be made for aid and information throughout.

Bids were asked for in due course, and Mr. Jesse P. Manahan of Monmouth Beach, proved to be the lowest bidder, for $5,300; that being the amount that we had estimated would be required. The contract was executed December 6th, 1906, and work was begun under it immediately.

After due consideration of the subject it seemed as if it would be fair to require the city of Elizabeth to contribute $1,000 toward the cost of the work, which would then divide the expense of the entire drainage almost evenly between the State and the city—the work of the previous years being figured into this account. I therefore, recommended that $4,300 be set aside out of the appropriation made under the law, and the director in accordance with this recommendation, did set aside that sum of money on condition that the city of Elizabeth provide for the balance of $1,000 required to complete the contract. That condition was fulfilled in due course.

The work on the Elizabeth marshes was unusually complicated. The right of way of the Newark branch of the Central Railroad of New Jersey passes directly through the marsh be-

tween the bay and the highland, without break from Bound creek to great Ditch at Elizabethport, and the entire area between the highland and the railroad was water-logged. There had been a ditch parallel to the embankment at one time, on both sides of the road, more or less continuous and affective; but these ditches had become blocked and on the west the railroad had itself blocked off a long section by putting in a "Y" and a spur toward Great Island. Cutting through the railroad embankment was out of question, so it became necessary to carry all the water on this immense marsh area into Bound creek, which was abundantly able to take it, or into Great Ditch, which was utterly inadequate as it then stood. A glance at the map, which is presented herewith, will make this condition clear.

So soft and water-logged had the meadow become in the course of time that any attempt to ditch as it stood would have resulted in almost inevitable failure.

The winter here proved an ally by putting the surface into condition to support the workmen, and during every moderate spell of weather the creeks were cleaned and deepened and the large ditches were put in. The result was, that as the spring came in, the water drained off more completely than for years back, and the surface became firm enough to hold the machines in some sections at least.

This winter work was really very difficult, very wearing on the men and very expensive; the frost was often from 6 to 8 inches below the surface, and tools as well as men suffered. Through it all, in cold and storm, Mr. Brehme directed and followed the work until the water ran freely and every chance to make an outlet was seized.

The spring tides and storms caused further delay, and when at the end of March the machines finally did get to work, the first brood of larvæ was in the pools. It was a smaller brood than the Elizabeth marshes ever had at the corresponding season, for more than half the territory was then already larva proof. Furthermore, a storm with heavy tide came in during the early days of April and, while it delayed work again for a few days, it brought killies into almost every pool, and by the

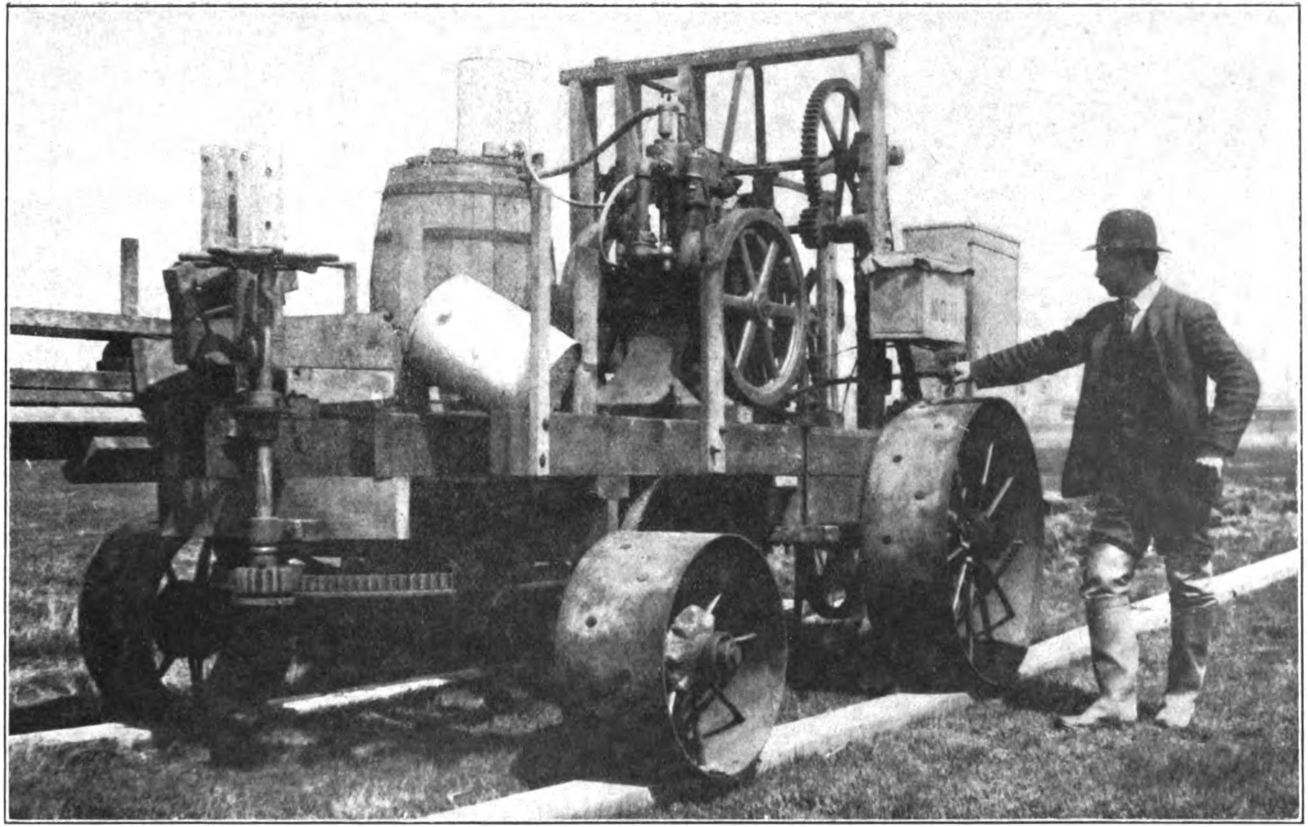


Figure IV.
The new model "True Ditcher" used by Contractor Jesse P. Manahan. **There are five of these machines in service.**

11th, only a few wrigglers remained in holes where no fish had been able to make their way.

April 29th, the second installment of larvæ had hatched from the over-wintered eggs, and the pools were swarming again with young wrigglers; but their breeding area was still further narrowed and every day dried out some new places and left the larvæ to drown in the mud bottoms. May 22d, the first brood of adults was on the wing, all *cantator,* and in such scant numbers that a migration to any considerable distance so as to cause trouble was out of the question.

The third larval brood was in the pools during the early days of June, and this was mostly *sollicitans*; so there were still over-wintered eggs that were hatching and not the results of this year's adults. Quite a lot of the mosquitoes that were present on the meadow at that time undoubtedly came on from the Linden marshes just below, and some of them almost surely from Staten Island, a small section of which, almost opposite Elizabethport was not properly drained at that time.

By the last days of June practically all the work was completed, and during the early days of July, practically within the time limit of the contract, the entire work was completed and certified for payment.

For variety, complications and obstructions, this meadow has not its equal in the State. Originally, with plenty of natural outlets for all the water that came on it, the artificial interruptions, chiefly by the Central Railroad of New Jersey, had completely changed its character and made it a pest hole in which mosquitoes bred out in uncountable millions. The original streams when blocked became stagnant dead ends, and the black grass, which makes excellent salt hay, was replaced by the useless reeds and other coarse, sedge-like vegetation. Besides, except during the winter, the marsh was almost impassable and it was positively dangerous for one not used to such territory to venture on it. East of the railroad line the problem was comparatively simple; west of that barrier it taxed all our resources to get the water off without expensive canals or drains of large size.

I had hoped to get the work just south of the Elizabeth meadows well under way before midsummer, but as I failed in this for reasons beyond my control, I feared that Elizabeth might not get the full benefit of the work done. Fortunately matters turned out better than I had hoped, as appears by the report of Mr. Richards, the Health Officer, under date of October 9th.

He writes: "The first noticeable appearance of the salt-marsh mosquitoes in 1907 was on August 4th, and they were troublesome for about two weeks. Since that time there have been almost no salt-marsh mosquitoes noticed in any part of the city except on the edge bordering the salt meadows, where they have been in evidence in small numbers until now. The flight in August was not a heavy one, and no great discomfort was experienced. They were mostly *sollicitans*."

"During June and July, in the house-to-house canvass which I had made this year, I had all cisterns noted, and on August 1st began to send out notices directing the owners to close and fill them up. Up to this date 344 cisterns have been closed and filled in with earth, thus removing them permanently from the city. It has been necessary, in many instances, to extend the time until early spring on account of expediency, so that by June 1st of next year we shall have removed a total of 400. You will see that this will help some.

"The cisterns which remain in the city are chiefly those in back kitchens or sheds within a covered building, and which will probably never be a menace so far as mosquito breeding is concerned.

"We have had considerable opposition in this work, and our motives have been misunderstood in many instances, and among others attributed to a desire to cause the installation of city water controlled by a private company. In July we thought that by the use of kerosene oil we could make all cisterns safe, and with this in view a list was furnished the oil man, and with one of our inspectors he treated all cisterns. This made them safe for awhile, but certainly stirred up a hornet's nest among the owners, and no second application was possible later on in the season. Although no harm was done to the water for washing purposes, it served as an excuse later on when notices were

served for the owners to vent their spite upon the Board of Health.

"The catch basins were oiled, over 800 in number, on the following dates: June 24-29, July 8-13, 22-27, August 8-13, 29-31, and September 9-13, making six treatments to each basin. Besides this, whatever stagnant pools were found in the city were treated during the season. The total cost for oiling was: Labor, $195.75; oil, 46 barrels, $115.03, making a total of $310.78.

"Owing to the rather cool summer, the water in cisterns did not become warm until September, and no breeding of any account was observed in them until this date. During September mosquito larvæ were observed in almost every cistern examined. This applies to cement or brick cisterns, and not to wooden casks. In these latter, mosquito larvæ were observed from June on.

"I have seen less than a dozen mosquitoes inside of houses this summer, and I have had absolutely no complaints on account of this species, so you will see from the above that we have had a remarkable year from a standpoint of mosquito absence."

This communication really speaks for itself and needs little comment or explanation. The flight of marsh mosquitoes in August came in part from the Linden marshes, and, probably, in part from Staten Island. The majority of the specimens remained on the drained marsh, and were noticeable throughout the latter part of the season along the edges. The New Jersey portion of this source of supply has been pretty well eliminated, the Staten Island portion is partly improved and the complete drainage has been provided for.

The most interesting feature of the account is the effective house-to-house campaign to locate breeding places for *Culex pipiens* and the persistent and systematic treatment of catch basins and other local breeding places. As to the effectiveness of the work done there can be no question, and each year this kind of work will lessen in amount as breeding places are permanently removed. Even the catch basin supply will in time become much reduced as the numbers of specimens are gradually lessened. Elizabeth was the first of the cities to become actively interested

in mosquito work, and it is at present in perhaps the best condition of any.

The local Board of Health and its efficient Health Officer deserve the highest praise for the effective work done.

Jersey City.

During the winter of 1906-07, the governing body provided the sum of $2,500.00 for mosquito work within the limits of Jersey City, in the form of an appropriation to the Board of Health. This appropriation came in answer to a request made by the Board, and the request was based upon the survey and estimates prepared by the office. The committee of the Board to whom the matter was referred consulted with me, and in due time notices were prepared and served upon the owners of the marsh land—very much more numerous, by the bye, than we had anticipated.

Where the owner could not be reached copies were posted on the land, and early in March all were in default, so that the Board had jurisdiction to carry on the work. Specifications were prepared by me and maps supplied, and bids were duly advertised for. Mr. Jesse P. Manahan, of Monmouth Beach, proved to be the lowest of the three bidders and the contract was awarded to him for the sum of $2,100.00.

Snow, storm and tides were all adverse, and although the work was started during the early days of April, progress was extremely slow because the water laid so deeply on the marsh and everything was soft and without texture sufficient to hold a ditch or to support the machines which had been relied upon to do a large portion of the work. Eventually it proved necessary to do most of the trenching by hand, but by means of special saws and other tools excellent results were obtained.

By the end of April one-quarter of the work was fully completed, and Mr. Henry Smellie, Inspector of the Board of Health, with Mr. Wm. Delaney, one of the Commissioners, had kept close watch on what was done. During the first week of May half the work was completed, and large gangs of men made use

Figure V.

Inspecting work on the Jersey City marsh. At the left, Mr. Smellie, the Health Officer; near the centre, Commissioner Delaney, chairman in charge of mosquito work; next is Commissioner Chesnutt, of the mosquito committee; at the right, Mr. Brehme, inspector for the office.

of the better weather conditions. But these same conditions also favored the development of mosquito larvæ, and on May 6th, on some parts of the meadow, myriads of them appeared in the pools. Development proceeded so rapidly that holes were filled with sods, and ditches were run without regard to continuity of work, simply to get off the water from the worst places. On May 10th I made rather a careful survey of the work, and arranged that if any large proportion of insects reached the pupal stage oil was to be used on all pools not completely dry. By the middle of the month, however, the danger was over; some of the insects did reach the pupal stage, but in spite of frequent heavy showers the ditches carried off the water so fast that very few adults came to maturity.

May 23d I covered the meadow again in a general way, and found that the brood of larvæ had been completely wiped out. There were not mosquitoes enough on the entire meadow to be annoying, and not enough to get into even the immediately adjacent parts of the city. There were only little odds and ends of ditching and filling to be completed, and only a few men remained at work.

A series of storm tides during the last days of May retarded the finish somewhat, but gave an excellent chance to test the effectiveness of the work done. It was found that where the entire meadow was covered at high water, so that every depression was bank full, the following low water carried off everything within 25 feet of each side of each ditch, and at a distance of 50 feet left only a small remnant, which disappeared at the next period of ebb. The work, therefore, is sufficient to completely drain the entire marsh within 40 hours after it has been entirely covered by tidewater.

June 10th the work was entirely completed, and the contractor received a certificate to that effect. Messrs. Smellie and Delaney, for the Board of Health, verified all the work done and expressed their satisfaction.

While the bulk of the mosquitoes infesting Jersey City were undoubtedly salt-marsh migrants they were not by any means the only species in fault. This was realized by the Board, and, as they had an unexpended balance of $400.00, they invested in a

spraying outfit and a supply of fuel oil. Mr. Brehme accompanied Commissioner Delaney May 15th, and again June 18th, on a tour through the city, locating danger points and places that seemed to require treatment.

Until midsummer Jersey City enjoyed a novel freedom from mosquito troubles. Windows were left open, unscreened, screened porches were abandoned for the open piazza or stoop, and the community hardly realized that summer conditions actually existed. Late in August, however, conditions became worse. The local supply of dirty-water species became abundant enough to be annoying, and increased steadily during early September. The unwonted freedom during the early summer made these later troubles much more annoying than would otherwise have been the case, and yet every one realized that the "swarms" of other years were absent.

During the early part of October I wrote Mr. Wm. Delaney, Chairman of the Committee on Mosquito Work of the Board of Health, and under date of the 21st of that month I received the following reply:

"Dear Sir—In reply to your communication of October 10th, in reference to the mosquito problem in Jersey City, I have the honor to inform you that the efforts put forth under your direction during the past summer, particularly the ditching of the meadows, have proven successful. All reports from that beautiful residential section of the city adjacent to the West Side Park, where the *Culex sollicitans* have been so annoying in former years, have been so favorable that I am sure the work is appreciated, and that for the first time in the memory of a resident of Jersey City the city has, during the past summer, been practically free from the annoyance of the latter species of mosquitoes.

"The *Culex pipiens,* however, have been quite troublesome since the latter part of August. Until then the circumscribed pools or breeding places in the city were treated with fuel oil, and the breeding of this species was successfully prohibited. But, owing to a severe illness, I was compelled to abandon the supervision of the work, and the result was that the pest got ahead of us, and on September 1st the work was suspended on account of

the appropriation for such work being exhausted. The work done, however, showed a marked improvement over former years, and I have secured an ample appropriation for next summer, and, with intelligent and persistent effort, I am sure the results will be most gratifying.

"I now want to call your attention to the meadows on the New York bay shore east of the Central railroad track and south of Jersey City, where we were led to believe no mosquitoes were bred. On June 4th Mr. Brehme and myself inspected that territory, and found that it was a very fertile breeding place. I immediately set men to work oiling, and successfully prohibited furthere breeding there. I have secured an appropriation from the Board of Finance for the ditching of these meadows, and the work will be started in the early spring.

"Your attention is also called to our neighboring city of Bayonne, where I believe the pest is bred to an alarming extent, and, as we are only across the street from Bayonne, it would seem miraculous if we did not get many mosquitoes from that section; also that part of the meadows lying south of the Penhorn creek, in the vicinity of Snake Hill, in the township of Secaucus."

As to the Bayonne conditions, these are in course of improvement, and will probably be eliminated as a source of danger early in 1908.

As to the Secaucus area, that development was a totally unexpected one. This meadow has been inspected every year since we began work, by both Mr. Brehme and Mr. Grossbeck, and, while it has been reported as looking dangerous, no larvæ had at any time been actually found there. In early September, however, reports came of a flight of specimens across Newark into South Orange and Montclair, and the only possible source of supply, with the winds as they were, was this Secaucus marsh. Mr. Grossbeck was, therefore, sent to investigate, and found in the mass of pupa shells left in the pools, as well as in the swarms of adults then on the meadow, abundant proof that our suspicions were correct. The heavy rains of early September and a series of flood tides had kept the shallow depressions full of water long

enough to hatch and bring to maturity every egg that was on the meadow, and it is now restocked with eggs.

This meadow probably does not mature a brood of mosquitoes more than once a year. There are no large pools, the surface is very level and only shallow depressions are found at any point. But there is no way for the water to get away except by evaporation and soaking into the ground, and while, under ordinary conditions the surface water from either rain or tides will disappear in three or four days; yet under such conditions as occurred this year it will remain long enough to bring a brood of mosquitoes to maturity.

It goes without saying that this is one of the areas that will receive attention early in 1908.

Newark.

Those early swarms of mosquitoes that in years gone by invaded the city of Newark in May and at intervals thereafter during the summer, have ceased to exist. So far as the salt marsh mosquitoes are concerned, Newark is almost free. Up to midsummer mosquitoes were scarcely in evidence, and the band concerts in the East Side Park, close to the salt marshes, were enjoyed by hundreds of people without annoyance. The only flight from salt marshes came in early September from the Secaucus meadow, as explained under the Jersey City heading.

Nevertheless, Newark is by no means mosquito-free. In a rapidly growing city where new streets are being laid out, building operations are going on, and all sorts of improvements are under way, there are always depressions or holes that retain water long enough, under favorable circumstances, to develop the rain barrel species—*Culex pipiens*. There are still numerous open lots where water remains for long periods, and these serve as constant sources of supply.

But in addition to this, Newark is a great manufacturing city, and there are hundreds of establishments, large and small where vats, tanks, cisterns and other receptacles hold water more or less continually. That mosquitoes breed in such places, I know,

Figure VI.
The bog saws and the men that use them.

Figure VII.

Shows how the bog saws are used to cut the ditch sides along staked lines. Mr. Brehme with his measuring stick.

Figure VIII.
Taking out sods between the saw cuts with shovel and hook.

because the wrigglers have been actually found in immense numbers in the supply tanks in one factory and those vats are not different from hundreds of others in the city. And in the sewer basins there is yet a considerable source of supply; more abundant in the outskirts than in the heart of the city; but present more or less, everywhere. Too much praise cannot be given to the local board of health which has recognized its duty in the matter and has done all that lay within its power to carry it out.

The following communication speaks for itself:

"In reply to your favor of recent date, inviting me to send you a brief resumé of work done by the Newark Board of Health in its campaign of mosquito extermination to date, I submit the following, which you are at liberty to reproduce should you deem it of interest.

"The ditches which were cut under your supervision on that part of salt marsh meadow included within the boundary line of the city of Newark, covered an area of some 3,500 acres, worked perfectly the past summer, although some of the ditches are five years old, and the latest of them cut four years ago. Our Newark meadow was kept perfectly dry the past summer, with but one exception—the Ebeling tract—which, as you are aware, has given us more or less trouble because of the overflow of the Peddie Street sewer ditch. Mosquito-breeding on this section, however, was very light.

"I have kept an inspector steadily employed on our meadow, inspecting the ditches and keeping them free and open. His reports show very little breeding, which we kept under control by use of oil.

"While these ditches worked perfectly and there was no breeding on our meadow, still there seemed to be little relief from the mosquito pest in Newark up to and beginning with the summer of 1905. Upon investigation I discovered that the mosquitoes which had infested Newark, especially in the northern and western sections, in great swarms, were not the salt marsh variety, but were fresh water mosquitoes. I at once started an inspection of the entire city and discovered that Newark was completely surrounded by mosquito breeding; on the one side by the salt marsh variety, and on the other sides by countless breeding places of the fresh water variety.

"Beginning with the season of 1906, with the assistance of our inspectors, I located many breeding pools—some very large—and succeeded in getting rid of many of them either by draining into sewers, or filling them up. In several instances we had the city

scavenger fill them with garbage and ashes, while we also were liberal with our oil, and when we came across a pool that we could not drain, or fill in, and that oil could not cover, owing to weeds, we resorted to crude carbolic acid, which must be used with extreme care, but accomplished the purpose for which we used it, very satisfactorily. This work was kept up during the summer of 1906, and we obtained considerable relief.

"Beginning with the season of 1907 we went to work early. I recommended to the Board of Health that an extra inspector be allowed me, to devote his entire time to locating and doing away with breeding spots throughout the city. This was granted, and I took the inspector who had been at work on the meadows, and who was thoroughly familiar with mosquito breeding, for the city work, and employed a new man for the meadow work.

"The result of this warfare on the fresh water mosquito began to show satisfactory results before the summer was far advanced. The inspectors were given to understand that there would be no excuse received for breeding in their respective districts. They were told that when they discovered standing water in their districts they must either get rid of it, or keep it coated with oil.

"Newark, aside from an occasional spell the past summer when the mosquitoes were driven into our midst by heavy and steady winds, has been quite free from the pests. We will never obtain entire relief until Bloomfield, Belleville and Irvington, which are our neighbors, take steps to exterminate the mosquito breeding in their respective territories bordering our boundaries, as the mosquitoes are blown into Newark when the wind is favorable.

"We have learned much in the art of mosquito extermination during the few years we have been engaged in this work, and have now reached a stage nigh on to perfection.

"Each inspector knows just where water will stand in pools in his district, and after every rain visits the pools and sprays them with oil. In the meantime, during dry spells, he directs his energies toward having the holes filled. They also inspect every receptacle they find on their respective districts that will hold water, and when they are found to contain water, over they go, bottom side up.

"Newark has parted company with mosquitoes, and with each succeeding year we will see less of them.

"We are now winding up our campaign for this season, but will start out with renewed vigor in the spring and keep at it with a determination to rid Newark of all mosquito breeding.

"I have had the co-operation of Secretary Alonzo Church, of the Essex County Park Commission, who has kept the sewer basins in the parks free of all mosquito breeding.

"The cost to the city for the mosquito campaign during the past summer was comparatively small, and consisted of the following:

Labor. Caring for meadow ditching,	$184.21
Salary Mosquito Inspector—caring for and oiling inland pools of stagnant water, etc.,	217.04
Oil,	36.16
	$437.41

Respectfully,
JOHN W. DOBBINS,
Chairman, Special Com. on Mosquito Work."

Newark Addition.

When the marsh area belonging to the City of Newark was drained in 1903 and 1904 there was a small area just south of Bound Creek, extending from the Elizabeth City line to the Pennsylvania Railroad, which was not included in the contract. This tract was, until about three years ago, within the Waverly town limits, and was not then considered as within the Newark work. The area was not a bad breeding section, and was not considered a source of such danger as to warrant an application for more funds. Subsequent inspections showed that, although our estimate of it as a danger point was on the whole correct, there was, nevertheless, a constant development of small broods, which were always noticeable on the meadow and provided eggs for other sections.

We found also that on this area there was a series of ditches put in about 40 years ago, by a company that undertook to reclaim the meadow, but failed before the work was completed. About 35,000 feet of ditches, it turned out later, were on this area. Another section is north of Bound Creek, between Maple and Bound Creeks, the Peddie Street sewer and the Pennsylvania Railroad, and on that we found some 30,000 feet of old ditching.

It became a matter of great interest and importance to determine the condition of these ditches, and to see what changes so great a lapse of time had produced in their effectiveness. They were found to be almost level full of a soft material that proved

to be mostly dead grass, and after a careful examination by Mr. Brehme, assisted by Mr. Wm. J. Erhard, who during the summer is employed by the Newark Board of Health, Mr. Erhard was employed for three months at a total expense of $250.00 to clean out these ditches with the view of restoring their effectiveness if possible.

The work began in March, and was continued as opportunity and weather permitted, until the entire line of old ditching had been gone over. For fully half their depth the ditches were simply clogged by the dead grass that had accumulated in them year by year, and when that had been removed, they performed their work as well as ever. The walls were still clean and firm, and there seems to be no reason why they should not last another forty years.

The extent of the work was so great that the ditches were not cleaned at once to their full depth, sufficient being done, however, to remove surface water, and an addition of 1500 feet of new ditch was put in to relieve a few danger points. The result is an excellent clean piece of marsh land from which no mosquitoes need be expected in the near future.

Mr. Erhard was re-appointed for the summer by the Newark Board of Health; but with added duties as City Inspector, an assistant in marsh work being provided. These two men have in the course of the season continued the work of deepening these old ditches and restoring them to their former condition of activity.

The importance of this experimental work lies in the fact that it proves to demonstration that a properly cut ditch in a peat marsh lasts almost indefinitely, and may be restored to activity after years of neglect. With a very little care annually such ditches never cease work and the permanence of the improvement now being made in the meadow conditions may be considered demonstrated beyond reasonable question.

Linden Township.

Inspections made during the season of 1906 proved that just south of the Elizabeth river in the limits of Linden township,

Figure IX.
Filling deep holes on the marsh with sods from the ditches.

Figure X.

A sod-filled area on a salt marsh. This was a "rotten" area with numerous small, very deep holes that did not drain completely.

some exceedingly bad breeding places existed, from which the city of Elizabeth derived an abundant supply of mosquitoes at times when its own meadows ran short.

It was intended to take these meadows in hand very early in the season of 1907 in order to relieve Elizabeth from infestation that might lessen the apparent benefit derived from the work within its own limits. Formal notice was served upon the board of health of Linden township in February, 1907, and an apparent understanding established, so that it was believed that as soon as funds were available work might be begun; but delay after delay occurred, and for some reason the necessary action was not taken by the local authorities until June, long after the first brood had emerged from the meadow, and when the second brood was well under way. By the time the period limited in the notices had expired and bids had been called for, June was over, and the contract for drainage was not assigned until July 6th. Work was begun immediately and carried on as rapidly as circumstances permitted.

The Linden marsh area is one of those cut by railroad embankments, and in which the natural drainage has been interfered with; but not so seriously as in the case of the Elizabeth marsh, because more openings have been left for the escape of the water through the railroad dam. Along the bay shore there is a series of manufacturing establishments, one of them, that of the Grasselli Chemical Company, very extensive indeed, and the cinders and other refuse from these works have been used to fill around the works and along the bay shore. This also has interfered somewhat with the natural drainage by imposing a barrier along the shore which covered everything except the larger streams. The tendency, therefore, has been altogether to throw the water back on the meadow, and we found, in consequence, that the most serious breeding places and those that were most troublesome to deal with, were at the edge of the highland. Work was therefore begun at that point and the worst of the breeding places were disposed of in short order.

A large part of the marsh lying along Morse's creek is good solid meadow, which grows heavy crops of salt hay, and of this a large area is owned and cut by the Grasselli Company to obtain

material for packing. These meadows were already partially drained and little more was needed to put them into good shape.

Other sections lying southward to the Rahway river were much lower and more broken up, and there was considerable rotten meadow. Fortunately, the two or three large creeks that still have unrestricted outlets in the Kill and through the railroad embankments, proved sufficient to take our drainage ditches, and there was no delay on the contractor's part. The ditches along the edge of the highland were mostly cut by hand, while those on the broad meadow were cut mostly by machine; three machines being in service during most of the period.

Reference has been already made to the fact that there were some existing ditches on the marsh, and most of these were in such shape that it was necessary to clean and deepen in order to give proper outlet to the water. In view of the interruption of the direct drainage it was also necessary to put in a few large intercepting ditches, and these were made 20 inches wide, and some of them deeper than the regular ditches. The contract called for ditching as follows:

Existing ditches to be cleaned and put into proper shape,	14,272	feet
New ditches to be dug—		
20x36 inches,	400	"
20x30 inches,	1,980	"
10x30 inches,	248,160	"
Total new ditches,	250,540	"

A large part of the sods taken from the ditches were used in filling, especially along the rotten meadow bordering the Rahway river and toward the edge of the high land. The full amount of work required in the contract was completed, and payment was duly made after it had been carefully inspected and approved.

The completion of this meadow following the completion of the work on the Elizabeth marsh removed a source of danger to the city of Elizabeth, and also eliminated the most productive source of supply for the Orange Mountain settlements. Situated as this meadow is, between the Elizabeth and Rahway rivers, the insects that bred on it had a free range of flight along either

valley, and our experience has been that from this source a large part of the trouble in South Orange, Montclair, Summit, Short Hills and adjacent settlements arose. The report of the inspections made in those territories during the latter part of the season bears out this belief.

Rahway.

The city of Rahway is situated on the Rahway river, beginning about one mile west from its mouth. From the boundary of the city to its mouth there is marsh on both sides of the river, and for a short distance into the city there is an extension of salt marsh, which breeds mosquitoes in considerable quantity.

At about the same time that proceedings were begun for the drainage of the Linden marsh area, formal notice under the law, was also served upon the board of health of the city of Rahway. This body co-operated cordially, served the necessary notices, and in due course the municipal government made the small appropriation—two hundred dollars—that we believed to be necessary to drain that part of the salt marsh area lying within the city boundaries. Long before we succeeded in getting ready for the work on the Linden marsh, the money was available from the city of Rahway, and when the Linden contract was finally awarded, the contractor was instructed to extend his work along the Rahway river, so as to include the city work.

Fewer ditches than were counted upon were required; but the work of placing them was unusually difficult, because of the character of the territory, the impossibility of using the machines and the remoteness from the other work. It was also found that while less work than was estimated was actually required within the Rahway city limits, yet in order to make this work effective, more than would have been otherwise needed was required on the immediately adjacent parts of the Linden marsh. Practically the entire sum appropriated by the city was therefore needed to make effective the city work; but when completed a very good piece of drainage was accomplished, and all chance for mosquito breeding on the marsh area within the city was eliminated.

Rahway is in the direct line of flight for mosquitoes that breed on both sides of this river in both Linden and Woodbridge townships, and as soon as work was well under way in this region its influence was at once felt in the city. The health officer of the board assured me early in October, that during the latter part of the season there had been an altogether unusual freedom from the mosquito pest in the city, and that very few of the familiar salt marsh forms were in evidence. By the middle of September the work was completed, and shortly thereafter the contractor's bills were certified for payment.

Raritan Township Marshes.

From the mouth of the Raritan river and extending west and southwest along the windings of the river to within a few miles of the City of New Brunswick, a salt marsh extends, chiefly along the northern bank of the river, a small portion of which is in the Township of Woodbridge and a very considerable area in the Township of Raritan.

The Township of Raritan, although a very extensive one, is very thinly settled, the center of population, Metuchen, having been separated as an independent borough. The result is that the township is really very poor, although the borough within it is well-to-do. The borough of Metuchen suffers from the breeding places in Raritan township, and from that same breeding area the insects travel on an east and southeast wind to New Brunswick and along the river, sometimes even to Bound Brook and Somerville.

Surveys were made early in the season to supplement and correct the surveys made in previous years, and during the month of May the necessary formal notice was served upon the Board of Health, and a personal explanation of the character of the work intended was made at a meeting of the Board.

The ownership of this stretch of marsh area is very much divided, and there was so much uncertainty and difficulty in the matter of securing services that it was deemed best to advertise the notices in addition to posting them upon the marsh. So far as

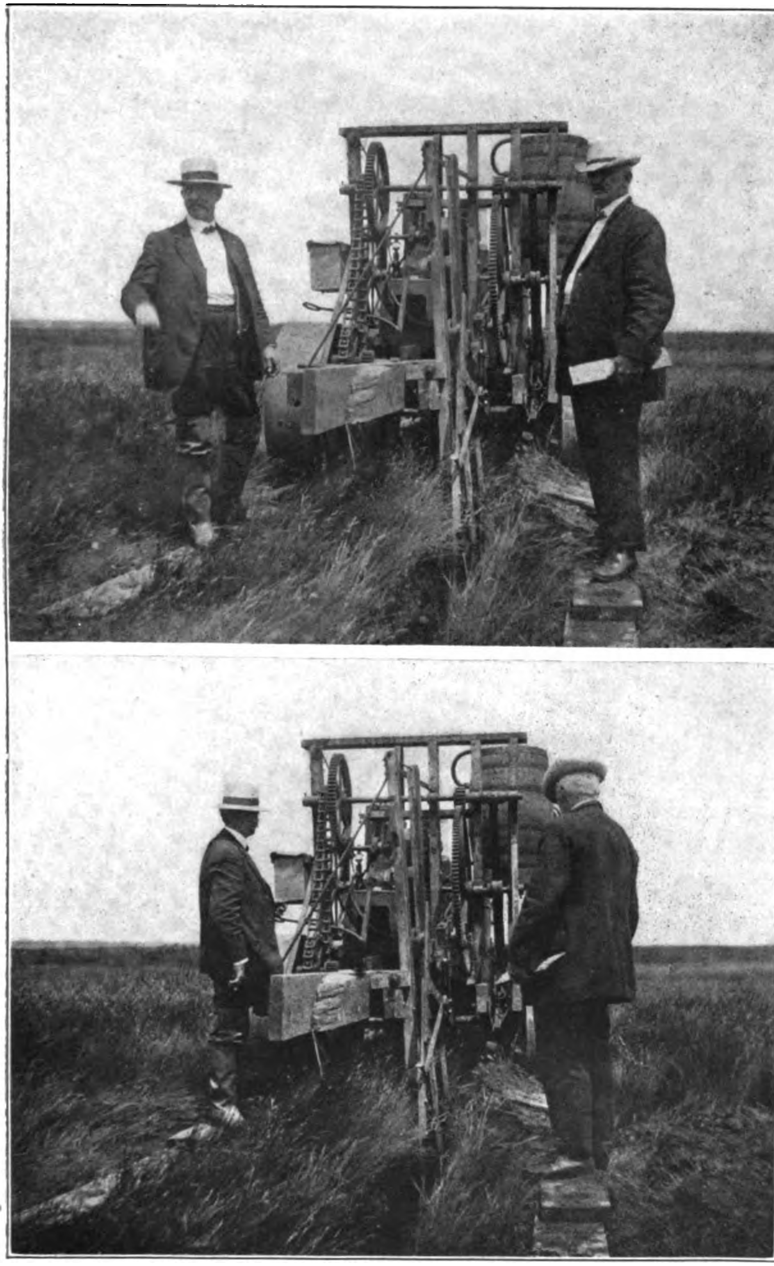


Figure XI.

Dr. E. B. Voorhees, Director, and Contractor J. P. Manahan, on the Raritan Marshes inspecting the work.

the owners were ascertained they were very cordial in their co-operation, and after all the preliminaries had been completed, the contract was awarded on the 1st day of June for the sum of three thousand four hundred and seventy-five dollars ($3,475.00), the work to be completed by the 1st day of October. About 169,000 feet of ditching were required, and a total area of 1,456 acres was treated.

No railroads cross this marsh area in such a way as to interfere with the drainage. There are several lines of "clay roads" that extend from the highlands directly to the Raritan river; but these are all parallel with the line of drainage, and did not in the least interfere with our work. Some of the owners of the large areas co-operated by cutting their hay before the ditches were put in, and thus made it easier to locate the danger spots that needed special treatment. This proved of incidental advantage to these same owners afterward, because the grass took a new start and made a second crop possible after the work had been completed,—something unheard of in marsh agriculture.

The conditions along a portion of this territory are somewhat different from those ordinarily encountered on river banks. For quite a little stretch along the stream, the bank is from 1 to 3 feet higher than the marsh area beyond it, forming a natural dyke which, however, is not sufficiently continuous to shut off the entrance of water on the marsh area. It is sufficient to prevent the running off of the surface water, and in consequence the territory beginning some 150 to 200 feet back from the river degenerated into rotten meadow, and in some places even into quagmire. This made it desirable to put in an intercepting ditch parallel with the course of the river, of larger size than the usual drainage ditches, and to carry only every fourth ditch through to the river itself. Except for this complication the work was straightaway, and most of the outlets go into the Raritan river itself.

The change in the meadow texture as soon as the surface water was given a chance to run off was most remarkable, and was considered almost incredible by those of the owners and inhabitants of the township that were sufficiently interested in the work to visit it. This was eminently a meadow for machine work,

since the ditches were very long and generally parallel. The work was competed well within the required period, and inspections subsequently made showed that the drainage is perfect.

One rather unexpected danger developed late in the season. It appears that this marsh is a favorite resort for certain kinds of wild ducks on their migrations, and that some of the larger pools on the meadow are visited by them to such an extent as to attract gunners. Our drainage operations have eliminated these duck ponds, and intimations were made by some of those who had been in the habit of gunning over these meadows that when duck season came around, these ponds would be again found as full as ever, and that they would stay there. In other words, there seems to be some intention of filling or blocking the ditches that have been cut, for the purpose of restoring the marshes to their wet condition, so as to favor the duck hunters. The attention of some of the larger marsh owners and of the Raritan Board of Health has been called to this matter, and a patrol system has been suggested that would at least locate any blockages and favor their prompt removal. At the present time there is no way of getting at or punishing those that may interfere with the drainge system, except through the action of the Board of Health, which is both slow and indirect.

Sayreville.

The Board of Health and other officials in the Township of Sayreville acted promptly in compliance with the notices served upon them, and the contract for draining the marsh lands was awarded July 1st and work was immediately started. The problem here was simple and only 26,500 feet of ditching was called for by the specifications. July 12th the preliminary work was completed, and on the 15th inspections to test drainage were made and supplemental ditches to perfect the work were laid out. Thereafter the action of rain and tide on the meadow was observed, and by the end of the month the work was finally completed. Subsequent heavy rain and tides left no pools capable of mosquito breeding within twenty-four hours after the meadow was covered.

The Roosevelt Marsh.

The borough of Roosevelt was created during the winter of 1905–1906 out of a portion of the township of Woodbridge, which contained Carteret as its principal center of population. The borough extends along the south shore of the Rahway river and along the borders of Arthur Kill to the present township line of Woodbridge.

There is a considerable area of salt marsh at the junction of the Rahway river with the Arthur Kill, and it is really a continuation of the Linden marsh area. As a breeding place it left nothing to be desired, and the output of this territory traveled along the line of the Rahway river, first into that city, and then continued onward along the course of the river into the Orange mountains. It was, therefore, one of those areas that I was particularly anxious to get hold of early in the season, and notice under the law was served on the present Board of Health on March 9th.

There seemed to be some misunderstanding as to the objects of the work, and some fear that the new borough would be saddled with a considerable increase of expenditure before its financial affairs were adjusted, and the Board of Health and the Council temporized, requesting a delay until the counsel of the Board, then dangerously ill should have recovered so that he could be consulted in the matter. In consequence of the delays caused in this way it was not until mid-July that all the requirements of the law had been complied with and that bids could be asked for. Under the conditions, as they existed, the entire cost of the work fell on the State appropriation. The contract for the work was dated on the first day of August, 1907, and the date of completion was specified as October first. Work was begun immediately, and was finished within the time limit of the contract.

The problem in this township was very simple. There is only one line of single-track railroad over the marsh area, and that has been run over bridges at all points where water courses of any size crossed the line of way. Quite a number of creeks extend through the marsh between the Rahway river and the edge of the

highland, and the marsh along the Kill is very narrow, so that outlets for ditches were abundant and conveniently located. No difficulties of any kind were encountered after the work was begun, and as soon as the matter was thoroughly understood by the authorities every facility for carrying on the work was afforded.

The contract price for this territory was one thousand four hundred dollars ($1,400.00). The area ditched was 640 acres, and the total number of feet of ditching was 93,000, of which 3,300 were 20 by 36 inches. The remainder had the usual width of 10 inches and depth of 30 inches.

Woodbridge Marshes.

The township of Woodbridge is unusually well provided with salt-marsh area. The township extends along the Arthur Kill, between the borough of Roosevelt and the city of Perth Amboy, and for almost the entire distance there is a marsh area cut by the broad railroad embankment at Port Reading. This railroad, however, does not in any way interfere with the drainage, and an unusual number of creeks cut into the marsh in such a way as to make it easy to get outlets for ditches. The meadow itself is a horribly bad one, full of holes and rotten in every sense of the word. It was almost impossible to get over some parts of it without hip boots, and an unusually large number of ditches was required to make the drainage complete.

From the Arthur Kill the township stretches across to the Raritan river, and on the north shore of that river marsh land extends from the Perth Amboy line to the Raritan township boundary, not so much directly on the river as along the course of the several creeks that empty into the river west of Florida Grove. The ditching scheme, therefore, does not drain directly into the Raritan except in a few instances, but into the creeks, which are deep, with good banks, and in all respects sufficient for the purpose.

In addition to the marshes on the Kill and the Raritan river there is another series along Woodbridge creek, extending from

its head to its mouth, a distance of about five miles along its various curves and twists. This territory is really the most dangerous of all from the mosquito-breeding standpoint, and the output is in excellent situation for flights inland, Metuchen getting the first choice from this source.

Altogether the area of infested marsh land was calculated as 1,616 acres, and the amount of ditching required was put at 145,100 feet.

All sorts of delays occurred before it was possible to comply with all the requirements of the law, and not until August 24th was the contract awarded to Messrs. Skinner and Wolfe, for two thousand five hundred dollars ($2,500.00). There was delay from the beginning. The contractors claimed to be all ready to go to work as soon as they could get their ditching machine on the meadows, but day after day passed and no start was made, one excuse succeeding another. Hand work with especially designed ditching spades was finally started a few days before the expiration of the time limit on the contract, and when that time limit expired, October 15th, less than one-fourth of the work had been done. Acting on the advice of the Attorney-General's office, and after ascertaining that the contract approved and filed in the Comptroller's office would hold the appropriation, I waived the time limit and allowed the contractors to go ahead, which they did, making good progress with their hand spades and doing clean work. Half the ditching, including all that along the Arthur Kill, was completed by the end of the fiscal year, and certificates were presented for payment. After that the work proceeded intermittently because of interruptions by high tides and storms, and was not completed at date of presenting this report.

The ditches are good, well made, and do their work. Those first put in are not so deep as is called for in the contract, but they are sufficient for their purpose, and those put in later are in all respects up to requirements. The ditching spades are excellent for their purpose, and the method of using them secures a straight ditch that comes as near perfection as can be reasonably demanded.

The work done in this township is of great importance to Rahway, Metuchen and New Brunswick, as well as to the settle-

ments within the township. To a less extent Perth and South Amboy are affected, and the resorts known as Florida Beach and Boynton Beach. The borough of Roosevelt has recently been separated from the township, and, as the financial affairs were yet unsettled when this work was undertaken, the Director, on my recommendation, set aside the total sum of two thousand five hundred dollars ($2,500.00) required to do the work out of the State appropriation.

Long Branch.

When the work on the Shrewsbury River was taken in hand by the local authorities in 1902 and 1903 there were left some few stretches beyond the jurisdiction of the communities that paid for the work. These were taken in hand in the following years, until all that remained was a small area within the City limits of Long Branch, on both sides of a small water course known as Troutman's Creek, which empties into Pleasure Bay, in a marsh area that was also more or less a breeding place.

After some correspondence with the local authorities I went over the city with some of the members of the Board of Health after making a personal inspection of the marsh area, and I pointed out such other places within the city as might be considered troublesome.

Formal notice under the law was afterward served upon the Board of Health which took such action as resulted in the appropriation by the municipality of a sufficient sum to do the work required.

The contract was awarded to Mr. Jesse P. Manahan for $180.00 and the work was completed early in October and certified for payment. It is unfortunate that it was not possible to get the wheels in motion early enough to prevent trouble during the summer; but it is believed that, so far as marsh mosquitoes are concerned, Long Branch will suffer little in 1908, and this work also cleans up the last bit of salt marsh breeding territory on the Shrewsbury River.

Township of Middletown.

In this township, extending along the shores of Sandy Hook Bay, there are three areas of salt marsh between Keansburgh and Atlantic Highlands. The first and smallest of these contains about thirteen acres, and lies on both sides of a small creek that forms the boundary between the borough of Atlantic Highlands and the Township. The second of these is a much larger area extending from Leonards to Port Monmouth, on both sides of Ware and Compton's Creeks and their branches. The third area is along the course of Pews Creek and its branches, between Port Monmouth and Keansburgh, and is intermediate in area between the others

In 1906 the borough of Altantic Highlands, taking advantage of the law then in force, secured aid to the extent of three hundred and seventy-five dollars ($375.00) in constructing a bulkhead at the mouth of Many-mind Creek, and draining the marsh lands along that Creek, so as to eliminate the mosquito breeding places. This proved quite effective in reducing the trouble, but not to the extent hoped for, because of the near-by sources of supply on Sandy Hook and the adjacent township areas. That small area at its western boundary was especially troublesome, and application was made by some of the residents asking for a survey and, if possible, relief.

Accordingly, Mr. Brehme was sent to investigate, to prepare a drainage scheme, and to ascertain general conditions. Afterward I made two personal visits to the territory and recommended that two hundred dollars ($200.00) be set aside to drain the smallest of the 3 areas: it was all the money that could be paid out of the 1907 appropriation, and all that could be satisfactorily done this year.

The necessary notices were served, and in due time the contract was awarded and completed just before the close of the fiscal year; some 2,700 feet of ditching being required. The cost is altogether out of proportion to the amount of work required; and the major part of it is due to transportation and other expenses in getting to the ground and the time required to do the work.

The requisite notices for the larger areas were also served and the Board of Health has acquired jurisdiction to take immediate further action whenever additional funds are available. The largest of the areas is at present in hand for radical improvement in all save a small section at its western portion. When this work is completed it will eliminate a large portion of the mosquito breeding area and until the work in progress has been carried far enough to make it possible to judge of its effect, it is not considered wise to appropriate further sums for drainage on this area. On the other hand, it is also fair that where, at large individual expense, considerable areas of marsh are rendered fit for settlement, immediately adjacent breeding areas that lessen the value of the improvements made, should be eliminated. The completion of the drainage of mosquito breeding marsh areas in Middletown township is therefore one of the matters in contemplation for early in 1908.

Sandy Hook.

That stretch or strip of land, known as Sandy Hook, forming part of the easterly boundary of Raritan bay and the natural entrance to New York bay, is now under the jurisdiction of the United States Government and, of course, beyond the scope of the State work. Mosquitoes are known to be troublesome at Sandy Hook, and in past years I have had the territory surveyed and reports sent to the commanding officer, pointing out the danger spots.

In 1906 the borough of Atlantic Highlands availed itself of the law then in force, and drained and otherwise improved the marsh area within its limits, and also the outlet to Many-mind creek. Local interest in 1907 resulted in a movement to clean up other marsh areas in the vicinity, as detailed under the heading for Middletown township, and as Sandy Hook was well within the range of mosquito flights on a southeast wind, I again opened communication with Colonel (now General) Charles S. Smith, the Commandant, who courteously supplied a pass that enabled Mr. Brehme to make the necessary investigation.

The following copy of his report speaks for itself:

"Sir—I herewith present my report on the conditions found on Sandy Hook. A very bad breeding place was found along the railroad, about one-half mile north from the first guard house, coming in from Highland Beach, and larvæ are in the pools at the present time. Wind from the south will carry the mosquitoes bred on this meadow directly to the Proving Grounds, and a southeast wind will take them into Atlantic Highlands. This meadow is about one thousand feet in length and varies from 50 to 150 feet in width; the worst place is the railroad ditch, which has no outlet.

The meadow just north of the Government dyke is also a bad breeding section, and filling and ditching will have to be done here. South winds will bring these mosquitoes to the Proving Grounds, and southeast winds supply Atlantic Highlands.

Things are very bad along the railroad for a stretch of about three miles. Improvements have been made along this railroad, and the sand and dirt to make these improvements have been taken out along the sides of the embankment making holes which were filled with water to-day, and contained larvæ. Then there are some blind ditches, some with fish and more without; those without fish had larvæ, while the ones with fish were free of larvæ.

The only thing that can be done with these places is to fill them. I don't think that many of these mosquitoes get into Atlantic Highlands, but they follow the railroad to the Proving Grounds; dense woods are on each side of the railroad.

A road has been built from Highland Beach to the Proving Grounds, and for the biggest part of this road sand and dirt was used for an under layer. This material was taken from the side of the road, many holes were made and these are now ideal breeding places. Larvæ were in most of them to-day and these holes will have to be filled to make them safe.

Conditions have been wonderfully improved on and in the vicinity of the Proving Grounds, and especially near the hospital, which was the worst place near the Proving Grounds. The old waterway has been entirely filled in, and a straight 6 feet wide and 1 foot deep ditch was cut, and all the low places and holes filled in the best manner, and it is impossible for any more breed-

ing to take place there under the present conditions. The rest of the bad places on the Proving Grounds have also been filled and a good job was done. The trouble that remains is on the places mentioned in the first part of this report, and which are all south of the hospital to the guard house near Highland Beach. I walked up one way and down the other so I could see all conditions, and which were found as reported."

Practically this means that the breeding places to which attention was called in previous years have been eliminated; but that new ones have been created by works in which the drainage question was altogether ignored. The engineer is in some respects the greatest enemy to the mosquito crusade, though he might be and should be its greatest friend and most effective assistant.

A copy of this report which bears date of October 14th, 1907, was forwarded to the officer in command, with the request that such action as was necessary, be taken to bring the matter before the proper authorities.

It is a pleasure to be able to add that the subject received very prompt consideration, and there is every reason to believe that the elimination of these breeding places will be undertaken in the very near future.

Long Beach Township.

Among the first of the seashore resorts to manifest an interest in the mosquito work was the borough of Beach Haven, situated in Long Beach township, and in 1903 a considerable sum of money was expended in ditching work under the supervision of Messrs. Wagner and Mellor, then in the employ of the office. A description of this work appears in my report of 1904, with a sketch of the work done and a statement of the further requirements of the region.

The results of the work were very marked. Within the limits of the ditched area salt marsh mosquito breeding was almost entirely abolished, but a considerable number of breeding places for *Culex pipiens*, the common house mosquito, still remained. Through the efforts of the local Board of Health these danger

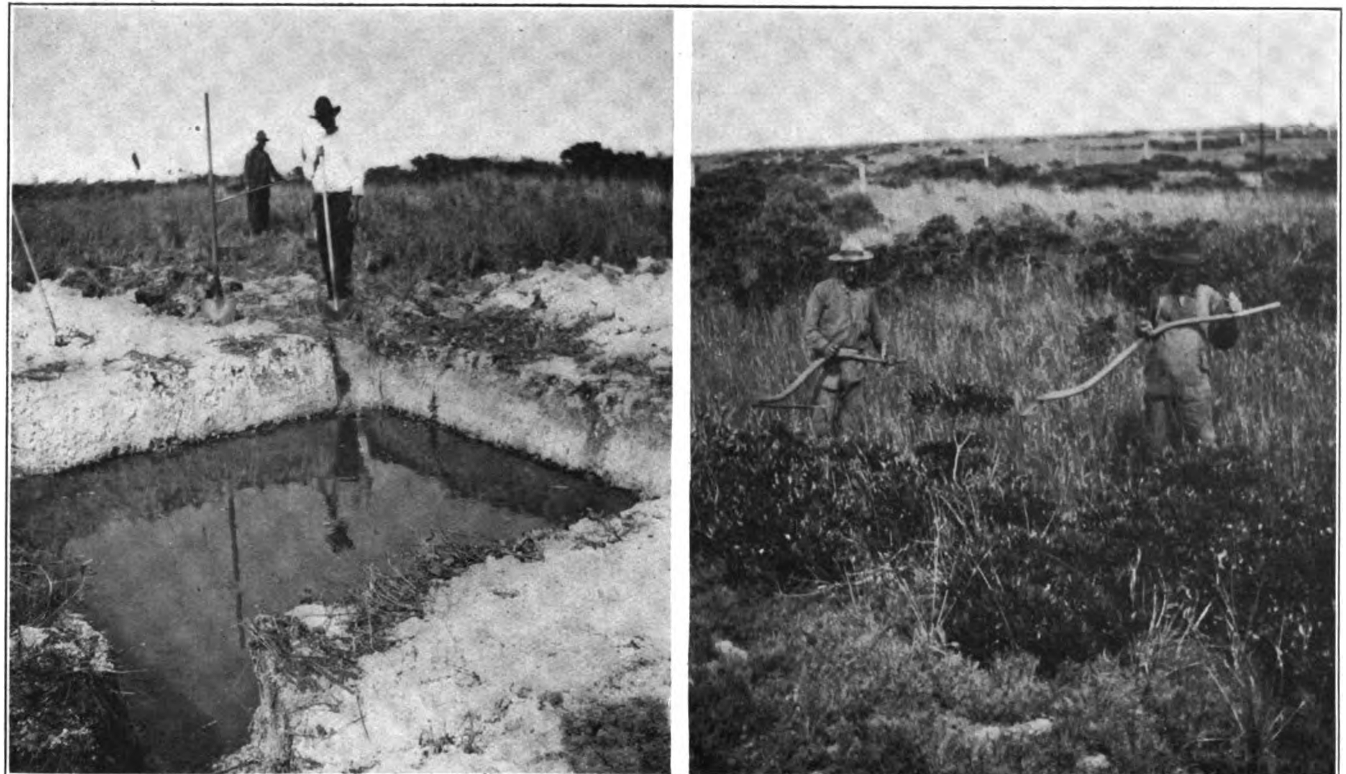


Figure XII.

To the right, cutting brush to fill depressions; to the left, draining a depression among the sand hills to a permanent pool stocked with fish.

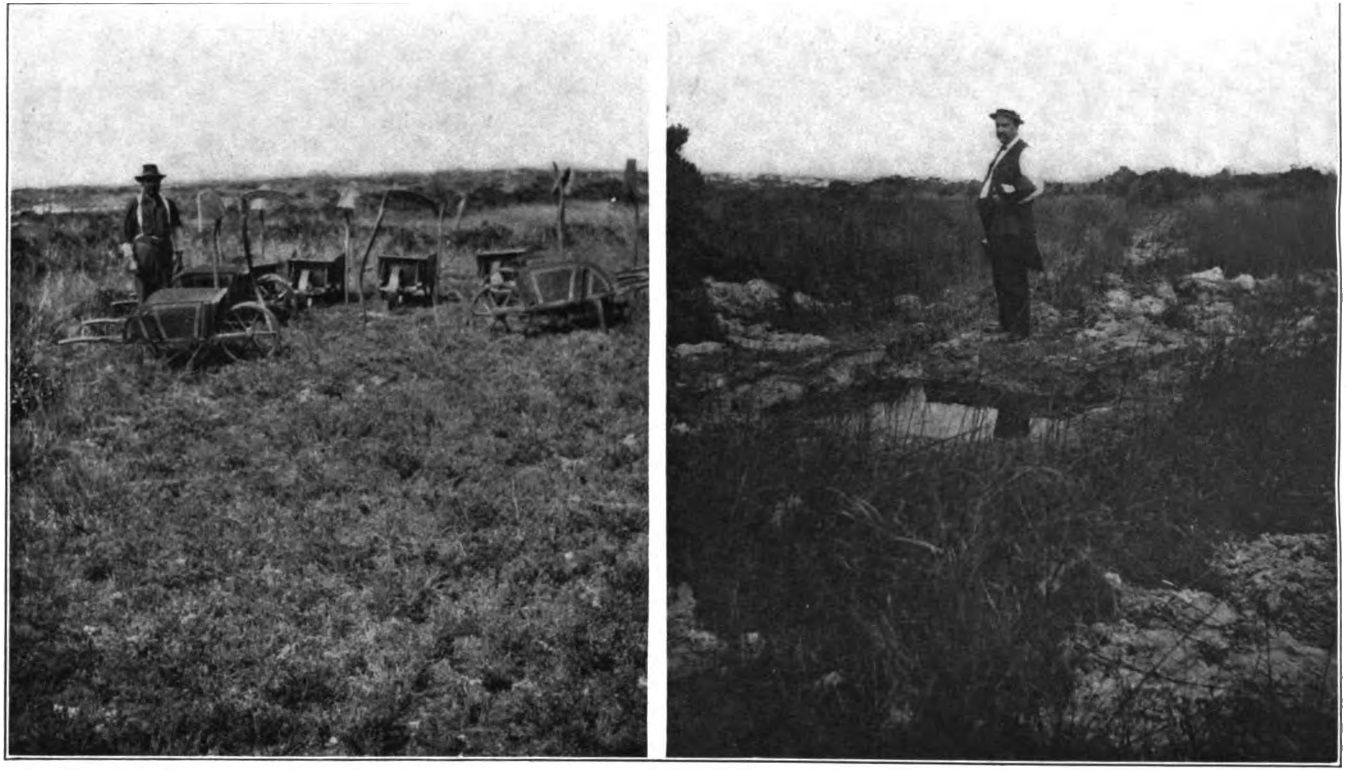


Figure XIII.

To the left, the outfit for grading and filling depressions among the sand hills; to the right, a breeding area drained to a permanent pool at the center.

Figure XIV.

To the left, carrying brush for filling; to the right, filling a small depressed breeding area with sand.

points have been gradually eliminated, and the borough is now in very good condition. But to the south there is a long stretch of sand hills and marsh, extending seven miles to the new inlet, and in this territory there were numerous exceedingly bad breeding places. Every south or southwest wind was likely to bring in swarms from these areas, and the borough did not get that measure of exemption which it seemed to deserve. To the north, extending almost fourteen miles to Barnegat City, matters were even worse; but as north winds on which mosquitoes fly are the exception, this was a minor source of trouble, only a few coming in on quiet sultry nights. The main shore to the west is a hot-bed for mosquito breeding, and a persistent west wind, lasting two or three days, may bring a flight across Little Egg Harbor bay. The problem is not simple, therefore, and when at the request of the authorities I undertook work in Long Beach township I realized that it was quite possible that there would be little or no apparent effect during the present season.

During the latter part of March I sent Mr. Brehme to Beach Haven to look over the ground to determine the condition of the ditches that were cut in 1903, and to plan out a ditching and general grading scheme that would be practical at a cost within the estimates already made.

His report, under date of March 22d, was extremely encouraging and satisfactory. As to the condition of the work done he said: "The ditches cut four years ago at Beach Haven were found the same depth as when they were cut. The sand is so compacted that a ditch can be cut anywhere on this meadow; it does not ooze up as was first expected. The ditches that were cut six inches in depth are six inches to-day; those that were cut twelve and fifteen inches have still the same depth. The ditches have not been looked after since they were cut, and there is not one on the meadow that has any vegetation growing up from the bottom. The only fault is that the hay cutters cut only to within one foot of the ditch, and the old grass finally lays over and hangs into the ditch. This could be prevented by burning the old grass in spring at little expense, and with an occasional going over in summer to keep the bay grass out of the mouths, the ditches would be in good working order. Even the shallow ditches that

were cut drain so well that wherever they were put in the meadow was dry. To find such conditions right after a heavy rain and snow such as we had on the 19th inst. is astonishing. While the drained portion of the meadow was found to be dry, the undrained section was found full of water. The grass on the undrained meadow was found to be ten inches in length; that on the drained portion measured twenty-eight inches."

Maps were prepared covering the entire area between Barnegat Junction and the New Inlet, and were served, with the usual notice, upon the Long Beach Board of Health, which took appropriate action early in June. In due course specifications were prepared and bids were invited, not only from the contractors who had competed for previous work, but from local contractors, and on June 14th I invited the contractors to go over the ground with me. Local labor conditions were such that no bids were made, but the territory was carefully examined by Mr. Jesse P. Manahan, who was the successful bidder, in company with Mr. Brehme and myself.

At this time Beach Haven was practically free from mosquitoes within the borough limits, and no active breeding places were found. To the south mosquitoes increased in abundance and became a veritable nuisance at Holgates, a mile away. It developed also that there were many more places that held water among the sand hills than were suspected, and that some of these depressions were so extensive that filling was out of the question. It was determined that such places should be drained to the low point, and the water gathered into a permanent pool that could be stocked with fish.

Work was begun July 10th among the sand hills, and, as it progressed, plans were somewhat modified and methods of work changed. Wherever it was possible water was given exit to the bay. When filling was done a base was prepared with grass and branches of sweet bay and beach plum, to make a bed upon which sand was piled to cover. This gives an excellent absorbing surface to the rain that falls, and prevents the sand from blowing; in fact, it will prove a sand catcher when the sand storms occur, and will aid in getting a more uniform level.

It was also found that the water level in these depressed areas was not much more than a foot beneath the surface, and that there was a variation in level of from three to four inches, due to tidal influence. Such ponds or pools as were dug, therefore, were made between two and three feet deep, and in the center of each pool a large barrel was sunk so that permanent water was secured. Into these pools "killies" were introduced, and they lived and flourished there to the end of the season. Throughout the summer these fillings and drainings worked perfectly. The heaviest rain-fall up to the end of September was fully absorbed in the fills as fast as it came down, and the pools did their work equally well, taking all the water from the ditches and sinking down to ground-water level within a day after the rains ceased. A period of dry weather favored the continuance of the work, and, during the entire month of July, neither Mr. Brehme nor myself found a single larva on the territory in course of improvement. But while there was little rain on Long Beach there were heavy showers on the mainland, and while the full-moon tides made no impression on the dry marshes of Long Beach the marshes on the Mullica river and along the shores of Great Bay were water-logged by them. During the last days of July reports came of immense broods of mosquitoes on the main shore, while in Beach Haven there were none. At my request Mr. Brehme attempted to make a collection of specimens for me, and by hard work among the grass in the evening on July 25th he secured less than a dozen old, worn examples. Practically there were no mosquitoes on Long Beach south of Beach Haven, and there were no larvæ in any of the territory on which work was going on. July 27th and 28th a west wind began to blow steadily, and I sent Mr. Brehme down to make observations August 1st, following myself on the 2d. All day August 1st the west wind continued, but no mosquitoes were noted during the day. A few began to appear in the evening, and on the morning of the 2d they were present in countless swarms in the grass along the bay shore, and much more abundant to the south than to the north. On the evening of the 2d, when I came down, the invasion was on in full force, and the hotel porches were uncomfortable, to say the least. Even on the beach itself there was

little relief, because the wind was still west. All night of the 2d the same wind held, and on the morning of the 3d I found matters about as bad as they could well be. On that day I went with Mr. Brehme over a large part of the territory where work had been done, and found not a trace of recent breeding. All the specimens now present were very fresh and clean examples of recent emergence. In the evening the wind became variable and shifted to the east, bringing first fog and then rain. On the hotel porches it was sultry, and everybody was fighting mosquitoes, which furnished the almost exclusive topic of conversation.

On the 4th covered the area from Beach Haven north to Life Saving Station No. 21, and while the rain of the previous night had left plenty of pools there were absolutely no larvæ, and there was no sign of recent breeding. It was certain that the invasion at Beach Haven and to the south had not come from this area, where no work had been done and where there were now breeding pools in abundance.

On the 5th Mr. Brehme went to the edge of the marsh on the mainland east of Barnegat, and there he found great numbers of pools filled with pupæ and pupal shells from which adults had emerged, and this was the condition throughout the marsh. Males and females were found here in abundance, while on our two days' tramp on Long Beach not a male was found. On the evening of the 4th I did find a few dancing males at the edge of the town, but few out of all proportion to the multitude of females.

That these mosquitoes that came in swarms to Long Beach on August 1st, 2d and 3d came from the mainland and were not hatched on Long Beach is absolutely beyond question, and demonstrates the utter futility of local work only at any point in line with a flight from a bad breeding area. It proves that in 1903 I underestimated the travelling powers of the insects and the danger from the west winds. I am informed, however, that west winds of so long duration are very unusual, and it was the coincidence of a heavy brood on the mainland just emerging, and a continuous west wind to guide the migrating swarms, that determined this enormous influx on Long Beach. As a consequence of this combination the supply that normally overruns the pine

belt was very materially cut, and Mr. Brakeley informs me that *sollicitans* was much less abundant than usual at Lahaway, and that there was no early August swarm. The flight was to the east instead of to the north, as in a normal season.

The rain of the 3d and 4th broke the droughty spell very effectually, and for several days there were more or less and sometimes very heavy showers. On August 8th and 9th Mr. Brehme was on the ground again, and now the pools that we had found so plentiful north of Beach Haven on the 4th were swarming with wrigglers well advanced in growth. The entire area to the south, so far as our operations had extended, was absolutely free from mosquito-breeding pools. Breeding was going on in some sections of the undrained meadow below Holgates, but among the sand hills not a pool was found and the system worked perfectly.

From this period on to the end of the month there was rain enough to keep the pools to the north in good breeding shape, and there was no chance for determining whether any additional flights came from the mainland.

August 21st there was another excessively heavy rain, and on the 22d Mr. Brehme again went over the area of work done to test results. Not a drop of water was found remaining in any of the fills; the center pools were all working, and the fish were actively running up the ditches so far as they were filled. The long ditch extending at the bottom of the depressed meadows was doing its work excellently well, and nowhere was there any accumulation sufficient to breed any number of mosquitoes.

By the end of the month the work was completed according to contract, and on September 10th I went over the entire ground with Mr. Brehme. At Sea Haven is Life-Saving Station No. 23, and between its station and the beach there is a long stretch of low marsh extending back to the lighthouse and beyond. This marsh had been ditched, and although it had rained heavily during the night, and indeed was raining while we were on the ground, the water was running out about as fast as it came down. This area is unsatisfactory because it is very little above mean high water in the bay, and there is a chance of ditches clogging by the washing in of eel grass and other sea weed. The St. Albans

Realty Company, the owners of this tract, have been advised of conditions, and it has been suggested to them that when the dredging fills that were in contemplation were made, this area should certainly be filled; especially at its head. About a mile south of Beach Haven begins a series of extensive glades among the sand hills, and this reaches to the bay side about three-quarters of a mile below Holgates. These glades or depressions are irregular in form and size, but are mostly connected, and there is a distinct low point that is marked by pools and shallow ponds until a short creek is reached that empties into the bay. Along the bottom of this trough a ditch two feet or more in width and varying in depth was cut until the creek was reached, altogether nearly three-quarters of a mile, and this is really an artificial creek, following natural contour lines. Into this creek lead ditches laid out through the low points of the connecting glades, until there is a series of lines through every low point, and all the water that falls on the ground is given a natural outlet. The shallow pools were all drained in spite of the heavy rains, and turtles and other animals were moving about in the soft mud or taking refuge in the ditches. The larger, deeper ponds simply form now an enlargement of the creek. They rise and fall with the tide, and are abundantly stocked with fish and other life. Already the drainage was assuming a natural appearance, and with a little looking after next spring to make the lines of this creek conform more perfectly to natural contours, the system will last for years unless interfered with.

Altogether the work done here in Long Beach Township has been interesting and instructive. It has demonstrated the possibility of completely eliminating mosquito breeding places in territory of this kind at a reasonable cost, and it has shown that even in poor communities work can be done with material abundantly at hand to improve the physical condition of that large area of shore territory of which Long Beach is typical. The entire Barnegat Bay district is affected by the results obtained in this work, for it has shown very clearly how future operations may be best and most effectively carried on.

Late in October Mr. Brehme made another trip to Beach Haven and makes the following record:

"An occurrence at Peahala on October 23d, the day before I got there, is well worth noting. On and for about a week before that date Peahala was practically free of mosquitoes. About one o'clock the wind from the south died out, and there was no wind for two hours. At three o'clock a very light wind set in from the west, and at four o'clock Peahala was swamped with *sollicitans* so bad that the men could do nothing but fight mosquitoes. Messrs. White and West, and several of the residents were at the edge of the meadow at the time, and they noticed the swarms of mosquitoes come across the bay."

"When I got down Thursday, the 24th, I found thousands of fresh bred *sollicitans*, and by the looks of things a very large brood emerged on the mainland meadow. I could find no trace of breeding on Long Beach, almost every hole is dry.

"I also made an inspection south of Beach Haven. The fish in the drainage pools are still alive, and no larvæ or traces of breeding could be found anywhere. But mosquitoes were there, fresh and in plenty, which doubtless came from the same places as the lot further north."

The Orange Mountain Area.

It has been my claim and my belief that when the salt marsh areas at the mouth of the Elizabeth and Rahway rivers were drained, a large part of the Orange Mountain mosquito problem would disappear. There was an opportunity to test my belief this season, both as to the source of the specimens and the effect of the drainage.

During the latter part of April all the members of the staff, Mr. Brehme, Mr. Grossbeck and myself, went over the territory between South Orange and Millburn to verify local conditions, to make some experiments with "Killarvæ," and to advise with Mr. William W. Renwick as to methods of dealing with local breeding places.

Up to the middle of May nothing was seen of any marsh mosquitoes anywhere. On May 18th Mr. Brehme reported a heavy brood maturing on the Linden marshes. At this time there were no mosquitoes on the Newark meadows, the broods on the Eliza-

beth marshes were almost under control, and only the Linden marsh at this point was untouched.

May 20th Mr. Brehme was on the South Orange Reservation collecting larvæ,and his report mentions the capture of a single female *cantator.*

May 24th, Mr. Grossbeck was detailed to work out the extent of the distribution of this brood, assuming they had followed their usual course. His report is as follows: "This was a clear, bright day; not one on which it would be expected that mosquitoes would be found in the dusty roads; nevertheless I had hardly stepped from the train at South Orange when I caught my first *cantator* on South Orange Avenue. I did not meet with any others until well on top the first ridge of the Orange Mountains and then several could be seen around me at any time. Here I broke into the wood and stirred up hundreds in the low shrubbery, many of which were swept into the net and determined to be all *cantator,* males and females mingled together. In the valley between the first and second ridges of the mountains I again broke into the woods and found things so near like what was found on top the ridge that I cannot say in which places mosquitoes were worst. On the top of the second ridge they were not nearly so bad as on the first and in the valley, though abundant enough; and this remained the same for a mile or so toward Millburn, when they began to diminish in numbers. As I neared Millburn they became scarce, and it would take considerable sweeping to get fifty. From Millburn I went to Short Hills in the vicinity of the pools where *C. abfitchii* were found in numbers as larvæ about two weeks previous. Surprisingly enough I did not see more than twenty adult *abfitchii* and did see almost as many *cantator.* Sweeping did not bring more to light: they were simply not about. Larvæ of *canadensis* were still in the pools, but the main brood had emerged and these were only stragglers. On the Orange Mountains I collected a few *canadensis* larvæ and pupæ as well as a small brood of *sylvestris,* among which several pupæ had already formed. A police officer who patrols the reservation told me that mosquitoes had made their appearance only about four days ago when, for the first time this year, he had to leave the porch and go indoors. In spite of the large brood of

canadensis that had emerged both on the Orange Mountains and at Short Hills, I only saw one adult of this species, which alighted on me but did not attempt to bite. In the evening I went to Passaic. The proprietor of the Shady Side Hotel told me that for the past four or five nights it was impossible to stay outdoors and that below the electric lights in the bar-room numbers were swept away daily. At the "Pagoda," which like the Shady Side Hotel, is situated directly on the brink of the Passaic River, I learned the same thing: that mosquitoes had made their appearance four or five days ago and were a nuisance since. By half-past seven I was seated on the porch of this latter hotel with an electric light over my head, and remained there until nine o'clock. Up to that time I caught one mosquito and was bitten by another. The one I took was *cantator*. Why I did not get more specimens after what has been said is undoubtedly because it was a very damp and chilly night, and not one that would draw mosquitoes.

May 25th. This day was much colder than yesterday and a brisk breeze was blowing that kept up all day. I began sweeping on the Garret Mountain at Paterson and in the first mile took one mosquito—*cantator*. I kept along the ridge to Montclair, and when near that place took two more mosquitoes in sweeping, which were also *cantator*. It appears therefore that the brood went in two directions: one along the Passaic River and another over Elizabeth and Newark into the Orange Mountains.

Mr. Dickerson reported *cantator*, males and females, at Nutley on May 19th. Females were also seen on the screens at the same place and time."

During the early part of June some of the residents of Passaic became interested in the mosquito question and located, as they supposed, the source of supply, just outside the city limits, in a low, swampy area, said to be always filled with mosquitoes.

Mr. Grossbeck was detailed on this service, and on June 20th covered the city conditions very thoroughly. His conclusion was that Passaic is a very clean city from the mosquito standpoint, and that very few develop within its limits. He located the areas complained of and found the mosquitoes; all worn specimens of *cantator* still active and ready to bite; the remnants of the brood that had come into the city about a month before.

The low moist area, overgrown with vegetation, forms an ideal hiding place for the insects and there they lurked during the day and from it sallied out at night after food.

July 19th, Mr. Grossbeck was again in the mountain, and during the entire day found not a single marsh mosquito. He met Mr. Renwick near Millburn, and learned that very few *cantator* had been seen during the season and no *sollicitans* at all. The locals were in abundance in their usual haunts; but improvements were under way in the wooded areas against these as well.

The rapid extension of the marsh work which practically put the Linden marshes out of service early in August as sources of supply, made it seem useless to keep this territory under continuous observation; but about the 20th of August reports began to appear of an invasion of mosquitoes at Paterson. I did not get copies of the papers containing the reports until some days later, and on the 29th and 30th Mr. Grossbeck was again sent over the territory with instructions to spend the night in Paterson, his old home, and report results.

He started in at South Orange and covered the usual course to Millburn and Short Hills. Not a marsh mosquito of any kind was found in the entire stretch and only a few examples of other species, which were collected and made no attempt to bite.

Paterson was reached late in the afternoon, and Mr. Grossbeck's report proceeds as follow: "I spent the evening at Paterson, stationing myself at the Passaic river on the east side of the city. The night was cool, but there was no wind stirring and in an hour and a half's stay I neither felt or heard any mosquitoes. On the morning of the next day I swept the grass along the river at this same point but saw no mosquitoes at all.

"The stories told by the people of Paterson of the recent invasion of mosquitoes are almost incredible; but are told so uniformly by the residents of different and remote sections of the city that they must be believed. The north and northwestern portions of the city are the only ones that seem to have escaped the invasion and these are the higher parts of Paterson. At one point I was told that twenty-four mosquitoes were killed in the morning in one room. From another person I heard that sleep

was impossible for the first night and that one member of the family bathed himself with kerosene and painted the screens and shutters with it, and that she herself was so severely bitten on the eye-lid as to be scarcely able to see in the morning. My sister, in the western section of the city, also was unable to sleep the first night, and had killed many of the adults in the morning, about eighteen of which she kept for me. All were very large and fresh, blood-filled *pipiens*.

All the indications are that no invasion of salt marsh mosquitoes struck the town; but that after a dry spell, followed by rains that formed pools simultaneously all over the city in which adults were induced to oviposit at once, a heavy brood of mosquitoes developed which reached maturity almost at one time. No attempt was made to investigate the matter further and to ascertain just where the mosquitoes bred."

That Mr. Grossbeck's conclusions are justified is indicated by two points: *First,* the eagerness to get indoors, which is a characteristic of the house mosquito and not of the marsh species. *Second,* the brief duration of the infliction. As soon as *pipiens* had fed it was ready to oviposit and disappear. Marsh mosquitoes would have hung about for a month, and could have been collected on the occasion of Mr. Grossbeck's visit.

There was no further trouble until September, and then a flight of marsh mosquitoes did strike across Newark and the Oranges and into Montclair—altogether the worst invasion of of the season. It lasted only a few days, was utterly unlooked for and disclosed an unsuspected breeding area in Secaucus. While it is matter for regret that this late flight should have formed a bad close to an otherwise clean record, it is also matter for congratulation that it came so late in the season as to be very brief and revealed a breeding territory which we can clean out early next spring before another brood has a chance to develop.

From all the Oranges and from Montclair the record is uniform and is expressed in the following letter from Mr. Spencer Miller, of South Orange: "My dear Dr. Smith—We were freer from mosquitoes in South Orange this year than ever before. We saw almost no marsh mosquitoes until September—I think

about the 15th. It might have been the 19th. I congratulate you on the salt marsh work and our own B. of H. for the way in which the locals were kept down. We drained one bad swamp under the Duffield law this summer, and the owner *paid in full.*"

And this brings me to the point that throughout this territory included in the first and second ridges of the Orange Mountains, the residents are becoming awakened to the possibilities of mosquito control or extermination. With the promise of relief from the flights of the marsh species, local work will tell, and the owners of woodlands are filling or draining the pot holes; the local municipalities are looking to the cleaning up of breeding places within their jurisdiction, and in October the Secretary of the Essex Park Commssion and one of his engineers, went over the Orange Mountain reservation with Mr. Renwick and Mr. Grossbeck to determine what work is required to clean up the territory included in the park system.

The Palisade Problem.

Complaints of mosquito troubles from the Palisade region have been received from time to time, and I have had the country examined in a general sort of way at the foot of the bluffs and along the crest, without discovering conditions that accounted for the occurrence of local species. It was finally found from collections made that the species in fault were the salt-marsh forms, and it was assumed that the supply came from the Hackensack valley on a west wind. But this summer the species were troublesome on the crest when there were no marsh mosquitoes in the Hackensack valley, and the assertion is made by those who have observed that the mosquitoes came in on an east and not a west wind.

In the early summer I went over a portion of Grantwood, one of the settlements on the Palisades near Fort Lee, at the invitation of the local improvement association, and could find no local conditions to justify any considerable mosquito trouble. To keep the matter under observation, however, I sent Mr. Grossbeck over the entire surroundings on July 25th, and again on August 19th.

In both instances he located several bad breeding places for *C. pipiens*, but this did not seem to be the species at fault, and the breeding places were well away from the center of population and west of the bluff. There was a general agreement that the trouble came in on an east wind, and Mr. Grossbeck, after his first visit, suggested that New York city might be in fault. The Hudson at this point is over a mile in width; there is no salt marsh along its shores, and the city intervenes between that point and the nearest salt-marsh area, so I was not inclined to fall in with this suggestion.

On his second visit in August Mr. Grossbeck again covered this territory, finding west of the crest a few examples of fresh *Culex sollicitans*. On the crest of the ridge, however, facing the river, that species became very much more abundant, and with it were examples of *C. tæniorhynchus*, which we had not found breeding on our marshes this year. There was an east wind blowing, and the specimens seemed to come in on that, all very fresh and in good condition as if only recently emerged. Mr. Grossbeck reasserted his conviction that the specimens were New York and not New Jersey products, and stated that salt-marsh areas were clearly visible from the edge of the Palisades, with nothing in the way of a direct flight from the marsh over the city to the top of the cliff, a total distance not exceeding five miles.

To test this point I sent him to the New York area August 27th, and he found an extensive salt marsh breeding area at the mouth of the Bronx river. Larvæ were found in numbers, as well as pupa shells and recent adults, and among the larvæ were those of *C. tæniorhynchus*, together with adults in sufficient number to indicate a fair percentage of the entire output. Now, as this species was not found at all this year on the New Jersey marshes in the areas about the mouth of the Hackensack, and it was notable on the Palisades, the conclusion that these Palisade examples came from this Bronx area was simply irresistible—they could not have come from any other point.

The matter was presented to Dr. A. H. Doty, who is in charge of the mosquito work for the city of New York, and he promised to have that area looked after and taken in hand, a promise that

he has started to fulfill by sending over the area Mr. Eugene Winship, one of his assistants, with instructions to ascertain the extent and location of the infested territory.

The attention of the authorities of Bronx Park, and of the Zoological and Botanical Gardens, was also called to this matter, and they have promised to co-operate in securing the drainage of this breeding area, which is, of course, a much greater nuisance to them than to their neighbors across the river. We are thus gradually narrowing the area of infestation and eliminating breeding places as fast as they are located. The city of New York will continue this work within its own limits until the entire marsh area is cleaned up.

Sussex and Warren Swamps.

To determine something of the character of the mosquito problem in the hilly, northern parts of the State Mr. Grossbeck put in two full days—July 10th and 11th—in driving from Hackettstown to Culvers Lake, collecting in the swamp areas along the Pequest and some of its tributaries and in the marshy areas along the borders of the lake. His results were of extreme interest and will be of value later, when the problem of dealing with conditions in that section of the State comes up practically. In the woodland everywhere, *Culex abfitchii* was found in swarms to equal the marsh mosquitoes along the sea coast; and usually that one species only occurred.

Abfitchii is a vicious biter, but sticks to its woods closely. Once within its haunts and the attack is prompt and fierce, and pursuit will extend even beyond the edge of the forest. But at 100 feet from the trees most of them have abandoned the chase, and at 200 feet only those that have had a taste of blood hang on for yet a little while. It is quite safe to go to the edge of the wood and to rest in the shade of the first trees; but at 25 feet within its precincts the attack begins. All these specimens were bred in May from temporary woodland pools and the adults which emerge in that month, hang on until late August.

This is in the region of the drained swamps where onions and other vegetables are largely grown, and Mr. Grossbeck had an

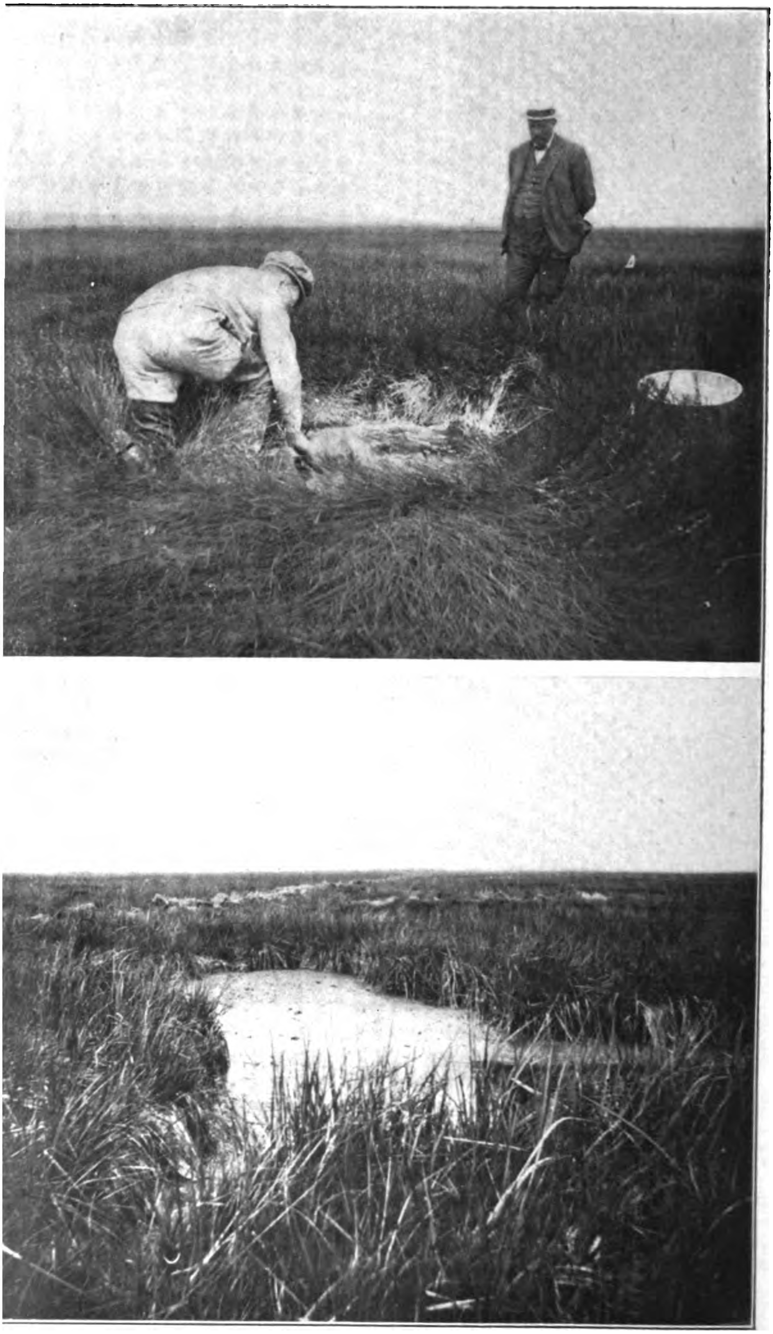


Figure XV.

Above: Dr. Nienstadt spreading "Killarvæ" on a breeding pool on Carteret arsh; below: a large pool treated with "Killarvæ," which turns the water lky for a short time.

opportunity of noting the character and effect of the ditching done. He reports that many ditches are suffering from neglect, are allowed to grow up and are losing their effectiveness.

In the more open depressed areas, where water was lodged, larvæ of *Anopheles* were everywhere found and with them, usually, those of *Culex territans*.

The character of the country changed somewhat south of Springdale, and more open swamp with cat-tails and tussocks was the prevailing feature. And here while larvæ of *Anophelès* were abundant in the pools, the troublesome adults were all either *Culex perturbans* or *C. aurifer:* sometimes one, sometimes the other; not infrequently both. These would attack and bite hard when their territory was entered; but never followed far, and it was easy to get out of their way.

The marsh between Swartswood Lake and Little Pond is composed of tussocks and high grass, with trees growing along the edges of the stream. The adults in this place were all *aurifer,* and they were present in immense numbers and extremely vicious. Around Culver's Lake both species were found, with *perturbans* far in the lead. As for larvæ, it was Anopheles everywhere and mostly very small. Even the stagnant pools in barn yards yielded no *pipiens*.

An interesting feature of the trip was that during the three evenings spent on hotel porches not a single mosquito was seen or felt. In other words, although there are mosquitoes in great abundance in parts of Warren and Sussex Counties they are mostly of such species as do not readily leave the immediate vicinity of their haunts, and do not make a practice of coming to towns or villages or getting into houses. Of *aurifer* and *abfitchii* this is absolutely true; of *perturbans* it is not.

Experiments with Killarvæ.

In the report for 1906 this material was referred to and the tests made with it were briefly detailed. Dr. Nienstadt was not satisfied that the unsatisfactory results obtained should be accepted as conclusive, and I was quite willing that it should have another trial. I did not believe that it could equal oil in general mosquito

work; but there are some cases where oil is undesirable, and where a cleaner, less offensive substitute would have a distinct field of usefulness. The early woodland species, *canadensis* and *abfitchii* seemed to offer good experimental material, and on April 27th, Dr. Nienstadt, Mr. Brehme and myself treated two typical woodland pools near Millburn. The practical work was all done by Dr. Nienstadt, the pools being located by Mr. Brehme and selected by me after determining the character of the wriggler fauna. There were a number of other pools in the vicinity that served as checks.

The material did not act at all as Dr. Nienstadt expected, and the larvæ persistently refused to die under observation; but I noted that the "Killarvæ" in the bottles collected as samples seemed to precipitate the organic material in the water, and I was quite ready to believe that the larvæ would die later from starvation, as they did.

A week later Mr. Brehme examined the pools carefully and reported a large percentage of the larvæ killed off. There were yet quite a number present and developing normally; but there had been a very decided thinning out, which was not found in untreated pools, and which is fairly to be credited to the mosquitocide.

On June 21st, Dr. Nienstadt gave a "demonstration" of the effect of his material at Hoboken, which, owing to a misunderstanding, was not attended by any member of the staff.

On August 6th, the material was tested on the salt marshes near Carteret, where Mr. Brehme had located some very fine breeding pools for *Culex sollicitans*. Here again Dr. Nienstadt treated several pools, some of them well stocked with larvæ, one of them stocked with fish—the latter being tested to determine the effect on animal life.

The application was liberal, and in a few minutes the lime had precipitated the organic material and formed a white coating over the bottom against which the mosquito population stood sharply outlined. Evidently the wrigglers did not like it, and made their way to the edges and to the shelter of the grasses; but while we watched they evinced no disposition to die off.

As this meadow was then in process of improvement Mr. Brehme had opportunity to observe these pools later, and he reports absolutely no bad effect on larvæ or other insects, and none on fish. In salt water the "Killarvæ" acts as a prompt clarifying agent, but the chemical reactions seem to be such as not to affect the animal life. Before the larvæ had completed their development the ditching gangs had reached this area and the breeding pools had disappeared.

The conclusions reached from the experiments of 1907 are not materially different from those reached in 1906. Used liberally the material kills wrigglers in fresh water; but it does so less by its direct effect, than by its indirect effect, killing the micro-organisms on which the larvæ feed, and thus starving them to death. The more confined the water area, the more active the insecticide. It is useful in woodland pools against the early spring mosquitoes. On the salt marsh it is good for nothing.

The Minnow Problem.

In the report for 1906 Mr. Wm. P. Seal gives his account of the work done in the attempted introduction of the top Minnow *Gambusia affinis,* into New Jersey. Apparently the experiment proved a failure and was recorded as probably such, so far as ocular evidence went. At present it is not so certain that the failure was as complete as at first believed, because for the first time in history, *Gambusia affinis* was found in New Jersey during the season of 1907.

Mr. Seal placed some 8,000 of the little fish in the tributaries of an ice pond at Westville in the late fall of 1905, and in 1906 failed to find any of them after the month of March. Investigating their possible whereabouts, he found a theretofore unsuspected connection between the pond and the Delaware River, and suggests that possibly they might have found their way to that stream.

During the summer of 1907 he collected in several of the tributaries of the Delaware; but these are generally of such a size and such a character as to make search for small fish that are not

present in large numbers a very uncertain matter. At all events he found nothing of the *Gambusia*.

In October, Mr. Henry W. Fowler, of the Academy of Natural Sciences of Philadelphia, and author of the fish book published by the New Jersey State Museum, found the species in some of the streams emptying into Delaware Bay and published the following note in "Science" for November 8th, 1907:

"Professor John B. Smith has called attention to the introduction of *Gambusia affinis* in New Jersey waters as a check to the development of the mosquito, as neither he nor his assistants have met with it in their investigations. It was, therefore, with considerable interest that quite recently Messrs. H. Walker Hand and O. H. Brown assisted me in fiding this little minnow in large numbers in Teal's Branch of Pond Creek, a small tributary of Delaware Bay at Higbee's Beach. We also found it very abundant in New England Creek, another tributary of Delaware Bay just north. There it was associated with large numbers of mostly young or small *Fundulus heteroclitus macrolepidotus, Lucania parva, Cyprinodon variegatus, Menidia menidia notata, Eupomotis gibbosus* and *Palæmonetes vulgaris*. The streams mentioned are mainly brackish, though fresh near their headwaters, more or less shallow with muddy bottoms, though with a clear even and gentle current. The males of *Gambusia* were equally abundant with the females, though the latter were usually larger. The accurrence of *Plethodon erythronotus* at Higbee's Beach is also interesting."

This occurrence is distinctly interesting: Mr. Seal is inclined to claim that the species is present as the result of his work in 1905 and points to the fact that the State of New Jersey has been thoroughly collected over by the best Ichthyologists of the country for many years, and that Mr. Fowler himself, in the preparation for his work on the New Jersey fishes collected very closely without finding it. Mr. Fowler doubts this conclusion and points to the fact that to reach their present habitat the fish had a journey of about ninety miles from their point of introduction. That they should make this and establish themselves in such numbers as do occur, in the presence of their natural enemies the sun-fish, he considers very unlikely, while not disputing the possibility.

Neither of these gentlemen seem inclined to believe in a recent natural introduction from a more southern point.

With the evidence as it stands at present a positive conclusion is impossible; but the fact is that *Gambusia affinis* has been found under natural conditions in New Jersey in such numbers as to make it reasonably certain that it is firmly established, and that there are other places in the State equally well adapted to it. On this point Mr. Fowler writes: "So far as the conditions at Cape May are concerned I do not think it unlikely but that they may be duplicated in other parts of the State. The *Gambusia* prefers a shallow, sluggish stream with clear water. Those taken by me were found in streams usually with a bottom of deep soft mud, the clear water flowing gently over it. The fish are sociable and were most always found with other small fishes and shrimps (salt water). Altogether it does seem very reasonable to assume *Gambusia* as indigenous to New Jersey when other features of its southern fauna and flora are considered."

Miscellaneous.

The time of the office force was pretty well taken up by the work that has been already reported upon, nevertheless there was a great deal done of an educational character that makes no subjects for report. Such are lectures that were delivered in a number of towns and cities in and out of the State, usually at the instance of improvement societies, and these have done much to impress upon the public the thoroughly practical character of the work intended and under way. There has been a steadily continuing demand for the Mosquito Report of 1902, the edition of which is now nearly exhausted, and many letters have been received and answered on matters relating to mosquito work. Especial effort has been made to continue in touch with the sanitary authorities, and especially the boards of health in the larger cities, which are recognizing more and more the importance of their duties in this campaign.

Special investigations have been made by Mr. Grossbeck, other than those mentioned elsewhere in the report, at Mount Holly and

Riverton, Burlington county; at Westville, Camden county; at Piscataway, Middlesex county, and in and about Trenton, Mercer county. On all of these works reports were made to the parties concerned, and some of these were acted upon.

Along the seashore numerous points were visited by Mr. Brehme at various periods, and an especial investigation was made at Sea Girt, where, by the bye, there is no local mosquito breeding on State property. On two occasions points on Long Island were visited at the request of communities, who paid his expenses, and there have been other requests for his services that could not be met.

Other States are becoming ever more interested in the campaign carried on in New Jersey, and are following her lead. New York City is a good second in the character and extent of the work under way; Pennsylvania has provided for a mosquito survey of that State; Maryland has begun work, especially in and about the city of Baltimore, and from several other States requests for information as to methods have been received. In medical societies, sanitary and public health associations, and in all bodies connected with hygienic work of any description, the mosquito subject has come up for discussion. It has been made the subject of magazine articles, and now receives universal respectful consideration in the newspapers. The time is ripe for a vigorous prosecution of the campaign.

NOTES ON THE MOSQUITOES OF THE SEASON.

BY JOHN A. GROSSBECK.

The season of 1907 was on the whole a normal one, though excessively dry for a time in the north, and, except for an occasional local outburst, most of the species of mosquitoes developed in their usual numbers without attracting any especial attention. For one usually uncommon species, however (*Culex perturbans*), the season—or perhaps it may have been the previous one—must have been peculiarly favorable, since it was found in practically all sections of the State, and in some localities in painful num-

Figure XVI.

Typical swamp area for breeding *Culex perturbans;* the larvæ are in the mud among the grass roots.

bers. This is the one mosquito in New Jersey with which we were entirely unfamiliar in the early stages. It is true that we do not yet know the larvæ of *Culex saxitilis* and *pallidohirta*, but both of these were bred from pupæ collected in the ordinary way from transient pools, and, therefore, sufficient is known of their early life to enable us to say that it does not differ from that of their allies. Prior to 1907 the discovery of the larva and breeding habits of *Culex perturbans* was a matter of scientific interest only, and only such time as was not taken up with more important matters was given to a search for them. But since it became of economic importance in one of New Jersey's pleasure parks, no effort was spared to determine its natural habitat. Persistence was rewarded with success, and its life history, with methods for its control, are detailed on another page.

As heretofore, the salt marsh mosquitoes were the principal offenders, and dominated the undrained parts of the coast, as well as the adjacent territory for miles inland. Owing to the lateness of the season the larvæ on the salt marsh developed slowly, and it was not until the middle of May that the first heavy brood, composed almost entirely of *Culex cantator*, was on the wing. From that time on, breeding was more or less continuous until late in the fall. *Culex sollicitans*, as is usual, almost completely replaced *cantator* in the latter half of the summer.

Taeniorhynchus was taken only once during the summer; two very fresh individuals at Grantwood, on August 19th. None were seen to develop on the New Jersey marshes, so it was supposed that these came over from the New York side. Later, on August 27th, larvæ were collected on Randall's Island in New York, which proved beyond a reasonable doubt that the specimens caught at Grantwood came from that source.

Culex salinarius was hardly noticed during the year, except in isolated examples in the larval stage toward the end of the summer, while *Anopheles crucians* was not taken at all.

Of the inland local mosquitoes, *Culex pipiens* was by far the worst, though locally *C. perturbans* far outranked it in numbers. A notable outbreak occurred in the city of Paterson and vicinity, between August 15th and 18th, where after a dry spell, followed

by frequent showers, *pipiens* developed in almost every section and came to maturity almost simultaneously. The inhabitants of the eastern and southern portions of the city suffered most severely, and they described the occurrence as terrible. Screens seem to have been practically of no avail in keeping the pests from entering dwellings, and sleepless nights were the rule throughout the affected area.

At Grantwood, on the Palisades, a breeding spot for *pipiens* was discovered which in the number of individuals it developed at one time stood unequalled so far as our experience is concerned. Here in a pool measuring 12 feet wide by 25 feet in length larvæ and pupæ crowded the surface so densely that at first it was thought a thick brown vegetable scum had formed over the water. A disturbance created a commotion which lasted for several minutes before the last of the larvæ could force its way through the living mass away from the apparent danger point. A dip of an ordinary water glass from this pool brought up between two and three thousand wrigglers!

Owing to the lateness of the spring the species of *Anopheles* were late in appearing, and not until the middle of July were larvæ found in any numbers, and then they were exceedingly small as a rule. *Punctipennis* was not as prevalent as heretofore; but *maculipennis* was rather unusually abundant. It was taken as a larva in several places in Warren and Sussex counties July 9th to 11th, and as an adult at Trenton, August 8th and October 10th, Paterson September 8th and Millburn October 1st.

Culex Perturbans.

The breeding habits of *Culex perturbans* having been at last discovered, a history of the search in New Jersey may be interesting.

Our first knowledge of the species came from Mr. J. T. Brakeley, of Lahaway, Ocean county, who, on May 27th, 1903, captured about twenty adults. His attention being called to the desirability of obtaining larvæ no pains were spared in collecting and noting the habits of the adults and in scouring the numerous

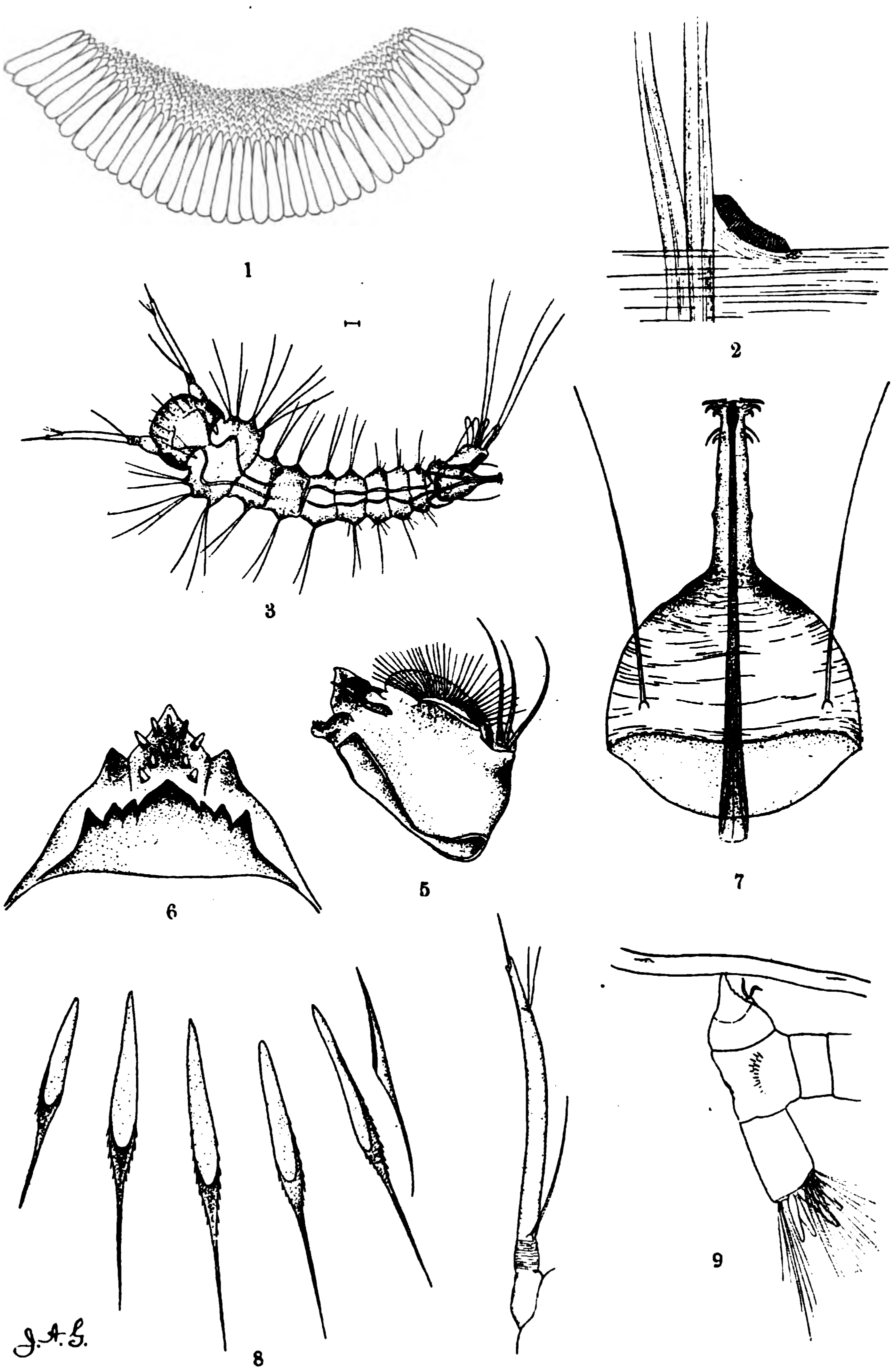


Figure XVII.

1, Egg-boat of *Culex perturbans;* 2, its position on the surface, resting against a grass stalk; 3, larva just out of egg; 4, its antenna; 5, mandible; 6, mentum with hypopharynx; 7, anal siphon; 8, lateral patch of scales; 9, shows how larva is attached to grass root; all more or less enlarged. Original.

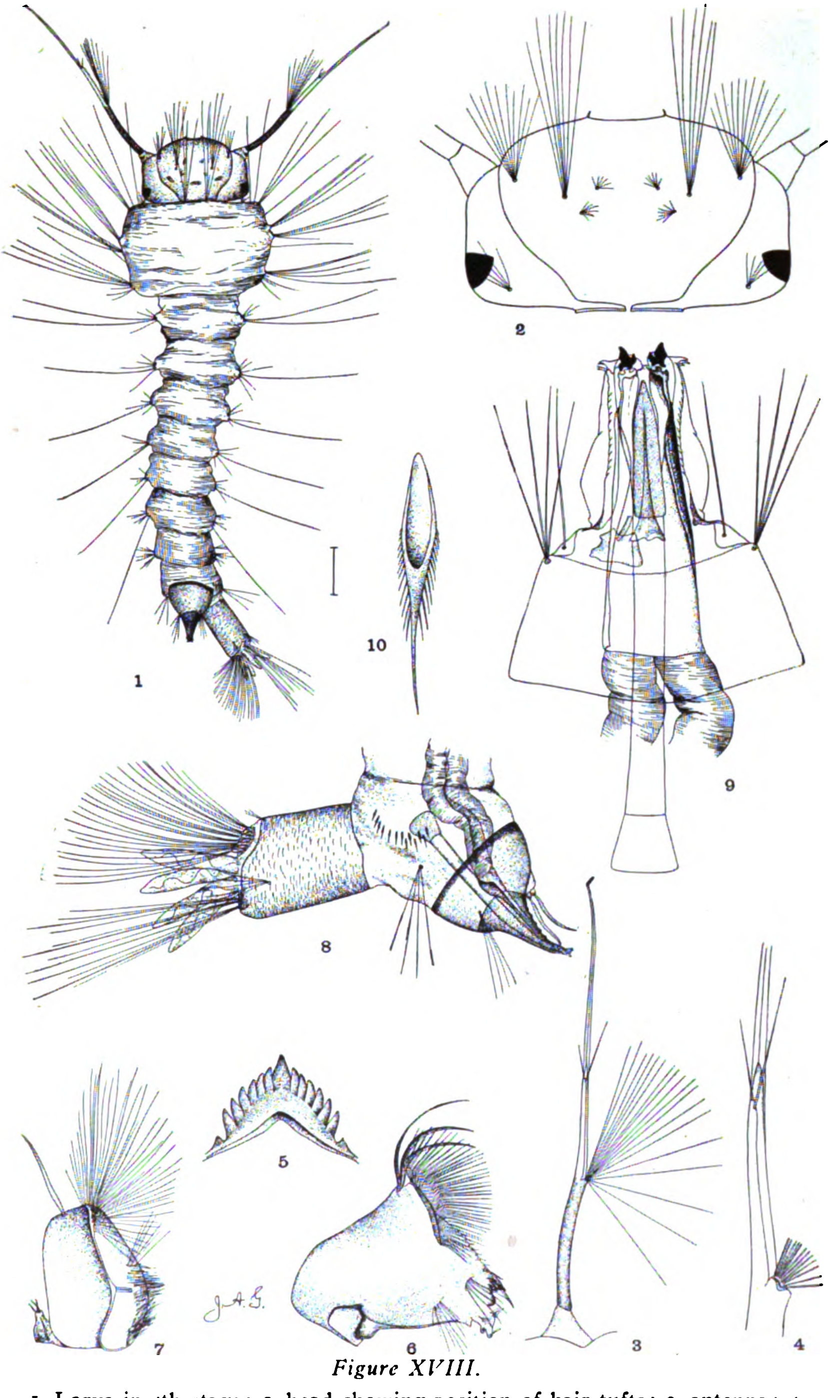


Figure XVIII.

1, Larva in 4th stage; 2, head showing position of hair tufts; 3, antenna; 4, part of same, yet more enlarged; 5, mentum; 6, mandible; 7, maxillary palpus; 8, caudal segments of larva; 9, anal siphon; 10, a single lateral scale; all more or less enlarged. Original.

water areas at and near Lahaway in an effort to locate the early stages. Fifty to one hundred adults were easily taken in the course of a single evening, but not a trace of the larva was discovered anywhere, though the search had been thorough and persistently carried out. At the end of the season's work Mr. Brakeley concluded that they must be migrants from some other place, and this opinion was strengthened by the fact that they appeared at the same time and apparently came in with the salt marsh mosquitoes.

On July 21st of the same year, several females and one male were taken at Lake Hopatcong, and on the 29th of that month a female with developed ova was caught in the Moonachi woods near Carlstadt.

Other captures in 1903 came from Cape May, July 28th, August 11th, and September 21st; Chester, Morris county, August 9th; South Orange, August 26th and Arlington. In none of these places were more than three or four specimens collected.

In 1904 and '05 not an adult was secured anywhere except at Lahaway, and there they were present in their usual abundance. On June 4th, of the later year, a male was among the captures:—the second specimen of that sex taken. Search for the larva was continued in these two years, and particular attention was paid to the cedar swamp between Barnegat and Manahawken, where it was supposed that they might breed and migrate to Lahaway. Areas to the south and west of Lahaway were also explored; but in no place was even as much as an adult found. In searching for larvæ no body of water was too small or too large to be passed without notice; with a net the surface and the bottom were swept, stones in the water were overturned, taken out and inspected, logs, branches and limbs of trees were drawn out in the hope of finding them clinging to their surfaces; the bottom material was scooped up and closely scrutinized, weeds and scums were investigated, and plant stems were even split open to see whether they contained larvæ; in short everything in the water, animate and inanimate was examined; but without success.

From the beginning the capture of *perturbans* so far inland as Lake Hopatcong rather opposed the idea that the species bred only along the borders of the salt marsh, and the fact that a male

was among those taken, was almost convincing to the contrary. Again, the fact that a male was taken also at Lahaway, pointed toward local breeding; but a decided argument that they did not breed at Lahaway lay in the fact that none of the females taken there showed traces of developing ova—a peculiarity true also of the salt water species that migrate from the marshes. Concerning the habits of the adults Mr. Brakeley says: "They are found all over, in the woods, in the open and on the cranberry bogs and get into one's ears and eyes; they get into the bed room and into the dining room and at the table they go for the ankles."

In 1906, adults were encountered in some numbers in the Great Piece meadow on August 27th, congregated over an acre or two of territory in the center of which was a large pool of water rather thickly overgrown with vegetation. Heretofore this pool had yielded only *Anopheles* and *C. territans;* but now it seemed obvious that it harbored *perturbans* as well. The mosquitoes were most abundant around the edges of the pool and disappeared completely at a distance of 150 feet from it. The most diligent search, however, failed to disclose a single larva of this species—all having apparently reached maturity. From a number of adults which were captured and confined in breeding jars, a single egg boat was secured on September 10th. This hatched two days later, but the resulting larvæ died a week after emerging, because they had not found the conditions suited to their existence. Yet the pails in which they were kept were provided with earth, stones, decayed wood and pieces of sod. We had now, however, associated the adults with a particular kind of breeding area, and were able to recall similar water areas at all of the points where adults had been taken. Furthermore, an egg boat could not pass the winter in that stage and if the adults hibernated, Mr. Brakeley would surely have found them in his cellar or barn collecting during the winter; so the only alternative was that they must hibernate as larvæ. Therefore, we concluded, that search in the late fall or early spring would most likely secure them. Unfortunately the pool in the Great Piece Meadow dried out in the fall of 1906, so the hope of obtaining larvæ from that source was destroyed. However, the field of search had narrowed down from

the entire water area of New Jersey, to small permanent bodies of water with plenty of vegetation.

The first record for 1907 came from Lahaway on June 17th, where Mr. Brakeley took several adults. Later they were found in large numbers at Trenton, where in evenings spent at "White City Park" from twenty-two to thirty were taken at single sittings between July 30th and August 8th. Other adults were taken in small numbers at Grantwood, Westville, Paterson and New Brunswick. At Springdale and Culver's Lake they occurred very commonly on July 10th, in company with the *C. aurifer*, and at Lahaway they were present in such enormous numbers that on one ocasion Mr. Brakeley took three hundred examples in fifty minutes. These were collected at the corner of a large lily pond just as night was falling. Mr. Brakeley believes that the species is arboreal in the day time, descending only as dusk comes on, and he bases his belief on the fact that in all his wanderings at Lahaway he has never taken an adult during the day. However, I took a few specimens there on August 1st, but the number was as nothing compared with the hordes which are present in the evening. In is interesting to note also that while they appear in swarms only at dusk, they disappear or at least materially decrease in numbers soon after dark and still later fall off almost entirely. At Culver's Lake, Springdale, and in the Great Piece Meadows they were common at all times during the day and did not hesitate to bite.

With the species so numerous at Lahaway it seemed to be by far the best place to search for larvæ, and on July 31st I went there to begin the search. Mr. Brakeley accompanied me during the first half day to point out the various water areas on his place. The first was a small pond about 25x35 feet and from 6 to 30 inches deep. The central portion was grown over with water lilies, two of the sides were bordered by a solid bank, while the other two were sloped off and supported a thick growth of vegetation in the shallow water. It appeared to be a typical *Anopheles* breeder, and a sweep of the net through the water after these, brought up an egg boat of *Culex perturbans*. Thus we had at the very outset discovered at least one of the breeding places of *perturbans*. But did they always breed there? Mr. Brakeley claimed not, as he had

time and again thoroughly investigated this pond and had never gotten a mosquito larva of any kind in it. A few minutes further search, by gently pressing the vegetation beneath the surface of the water, revealed three additional egg-boats. We next investigated a larger lily pond on the banks of which Mr. Brakeley had caught his 300 adults in fifty minutes. This was alive with small fish that were able to get to almost every point in the pond; nevertheless, along the shallow borders, I took egg-boat number five. A sixth egg-boat was taken from a sphagnum pond where we fished for *Corethrella brakeleyi.*

On August 1st I made a more thorough search of the small pond wherein four boats had been found on the day previous. No part of the water's surface was left unexamined, and in two hours 59 egg-boats were collected. All were found for three feet out along the shallow edges, where the vegetation was thickest and of a grassy nature. Along the other two sides the lilies grew close up to the edges, and here and in the center of the pond absolutely nothing was found.

The egg-boats were often clustered around a single stalk of grass, forming a star of from four to nine points, one end of the boat being drawn high up along the plant stem by capillary attraction, while the opposite end points directly away from the center.

Every part of the pond was searched for larvæ as well as egg-boats, but with the exception of one young larva, apparently just out of the egg, nothing was found. For a pond of this kind the water was remarkably free from insect or other life. In all, one small fish, three tadpoles, two dragon fly larvæ, fifteen small Dytiscid beetles, and one larva of *Uranotaenia sapphirina* were taken from it.

On August 6th, an open swamp, six or seven acres in extent, at Trenton adjoining Spring Lake, and which was previously suspected of being the source of the *perturbans* supply for the White City Park, was examined for eggs. In such an immense area and with the species so much less common than at Lahaway, the task was not a light one and at the end of half a day's work only twelve boats were collected. Most of these were fragments, found at widely separated places. On August 8th and 12th, other parts of this swamp were examined, and eggs were found all over;

though in certain spaces where the vegetation was not so thick or in free water, absolutely no traces of any could be seen. In all 57 egg-boats, complete or fragmentary, were taken on the Trenton swamp area. On August 8th a larva in the second stage of development was fished up with the bottom material, but continued searching in the same place failed to turn up additional specimens.

All the egg-boats collected at Trenton were given up to experimental purposes in an endeavor to bring the resulting young larvæ to maturity; but while all were failures it may not be uninteresting to note the various conditions to which they were subjected. First, it was found uterly impossibly to carry the egg-boats for even a short distance, because unlike those of *pipiens* they sink readily and apparently do not hatch when thus submerged. For this reason the experiments were carried on in a protected place near the swamp itself. A series of five two-quart jars three-fourths filed with water served as breeding places, and on August 8th fifteen boats were equally divided between them. No. 1 contained only water taken from the swamp; in No. 2 was placed two layers of turf; a third contained one layer of turf and a three inch layer of vegetable mould from the swamp; in No. 4 was a number of lily stems and in No. 5 an entire plant of arrow-leaf. On August 12th, the following was noted: No. 1, eggs not yet hatched; No. 2, larvæ hatched out and all dead; No. 3, one boat unhatched, others hatched and all larvæ dead; No. 4, no eggs hatched; No. 5, larvæ hatched and dead. Additional egg-boats were placed in each, and another jar, No. 6, was added, which contained grass with all the roots, while in No. 1 was put a seven inch layer of silt. August 16th, the following conditions were noted: No. 1, an active brood of young larvæ, burrowing some three-fourth inch down into the silt where they could be seen in small crevices wriggling vigorously; No. 2, a lot of young larvæ swimming about in the free water—none entering the turf; No. 3, a large brood of larvæ, all dead or nearly so; No. 4, larvæ hatched and all alive; none attached to lily stems; No. 5, larvæ out and all dead; No. 6, larvæ out and all dead. On August 26th, after a period of ten days, examined all the jars and found everything dead.

After this, experiments were abandoned, and it was decided to wait until late fall, to give the larvæ a chance to develop, and then to fish the small pond at Lahaway. Meanwhile Mr. Brakeley had been giving the subject some attention, and on September 21st, after fishing the pond in vain with his graduate, he pulled up a plant of tear-thumb grass, and from the roots washed out a larva in probably the third stage of development. Two other smaller larvæ were secured in the same way, and all were sent to the laboratory. With this information I went down to Trenton on September 27th, and with a small net fished the bottom material, where I had previously found eggs. When the water had finally trickled through the cloth, a mass of brown silt was left and in this were two well-grown larvæ. Others were taken in the same way, but it was not until the bases of the tussocks were swept that larvæ were really gotten in some numbers. Collecting was slow, on account of the fact that each sweep of the net would bring with it a mass of partly decomposed vegetable matter, and the fine silt would clog the meshes of the cheese cloth net. In all forty-seven wrigglers were taken in two hours, and they ranged in size from those apparently just out of the egg to those one-fourth of an inch long, and representing stages from one to four. The great majority were of the largest size. No larvæ were taken at a depth less than six inches from the surface, and most all at a depth of ten inches and over. Specimens could be gotten as far down as the net could be forced through the matted vegetable roots. Mr. Brakeley, continuing his washings, sent in six larvæ on September 26th, four on October 1st, four more on October 3rd, and eleven others on October 11th. Most of these were small, only three being in the third stage. Collections at Trenton turned up eighty larvæ on October 1st, one hundred and nine on October 3rd, forty-two on October 9th, and forty as late as November 1st.

Habits of the Larva. As before noted, the larva is not dependent upon the outer air for its existence, and, after once leaving the surface from the egg, probably never returns to it until it has assumed the pupal stage and is ready to emerge as an adult for flight in the open air. Unlike the larvæ of certain other mosquitoes in New Jersey, which rarely come to the surface, the anal

gills are not unusually developed, though they are provided with obvious trachea. It seems that in this case the wrigglers are able to obtain a supply of oxygen through the open cellular tissue of the roots of certain grasses, which they pierce with the curiously shaped air tube that is especially adapted for this purpose. They do not permanently anchor themselves to one spot on the root, but can very readily detach the tube and move to some other place. At the laboratory over one hundred larvæ were put in a two gallon jar into which was placed a portion of a tussock around which the larvæ were collected in the swamp. In a short time most of them had disappeared within the sod, though a number worked their way through and came out in the crevices on the other side where the sod rested against the glass, giving a splendid opportunity for study. Here they were seen to attach themselves to the grass-roots and sometimes remain in the same position for days; but would quickly let go and wriggle away if disturbed. Before piercing the plant tissue the larvæ often move along a root, tipping the tube against it as if feeling for a soft spot. After such a performance a favorable spot was usually located in a crotch where a rootlet divided from the main branch.

Just how far the larvæ go down into the swamp in winter, if they go down below the point at which they were collected at all, is not known at this time, and how the adult emerges from the pupa in late spring, is also a question which cannot be answered at present.

In collecting at Lahaway, November 10th, Prof. Smith found that the heavy rains had raised the July level of the small pond where I found the egg-boats over six inches, and that this had resulted in lifting the bottom vegetation so that it floated; leaving about six inches of open water between the bottom of the sod and the mud of the pond bottom. By getting the net through the floating sod and sweeping the root mass underneath, larvæ were obtained in every dip; but no larvæ were found in the bottom mud. The roots, then, are essential to the larvæ and they seem not to occur where none are present. This is also borne out by the observations made by me in the Trenton swamps.

Breeding places for perturbans and methods for their control. *Culex perturbans* is probably the nastiest of the inland mosquitoes

with which we have to deal. It has for its home just those kinds of swamps that are free from other mosquito life, and probably also the shallow borders of lakes which support a heavy vegetable growth. Such places are usually well supplied with predaceous water insects as well as other natural enemies of mosquito larvæ and even *Anopheles* is unable to maintain itself to any extent. But *perturbans* selects for its breeding, spots so thickly overgrown with vegetation that very few insects and no fish are able to penetrate. Thus the egg-boats are left unmolested and the larvæ as soon as hatched bore down into the mass of roots away from all ordinary foes. Hard bottomed tussock swamps probably never breed *perturbans*.. Such swamps as are apparently bottomless, that is, they are so boggy that solid footing cannot be gotten at any depth, serve as the haunts of the larvæ of that species.

Owing to the fact that the larvæ are not dependent upon atmospheric air for their supply of oxygen, and that they penetrate silt for some distance, they cannot be reached with the ordinary petroleum oils and lime mixtures. Draining the swamp by means of deep ditches, or the removal or thinning out of the vegetation to give fish and other enemies an opportunity to enter would be the most effective method and, in the long run, the least expensive in eradicating breeding areas. Nevertheless the insects are not altogether beyond our reach as the following experiments, carried on under the direction of Prof. Smith, will show.

Experiments with Phinotas Oil.—October 7th: A small amount of the oil was put into a jar containing about one gallon of water and sixty larvæ. It had no immediate effect upon them, but in two or three hours afterwards such as were swimming free in the water were seen to be sluggish in their movements. The next day, about twenty hours after the application, the water and grass sod were examined, and while most were dead three larvæ were washed from the sod, which were active and swam freely when changed to fresh water.

An approximately similar amount of the oil was put into a jar containing two gallons of water and one hundred larvæ. The oil in this case was forced down into the water by means of a pipette and bulb, whereas in the first jar it was put in gently. The material sank to the bottom very slowly and it was fully two hours

before it actually enveloped the sod. The next day, twenty hours afterward, only two larvæ were alive from the sod; the remainder were dead.

October 10th: Went to Trenton and selected a spot in the swamp where larvæ were present—six having been taken by the first dip of a net and four in the second. Here I staked out an area twelve feet square and from a sprinkling can poured one gallon of Phinotas oil evenly over the surface. The area, as is the whole swamp, is thickly overgrown with vegetation and at this time of the year was worse than in summer because of the dry grass falling down and forming a layer over the surface which must be penetrated before the grass roots, where the larvæ cling, are reached.

October 15th: Thoroughly examined the area treated with Phinotas oil on the 10th. Two hours were spent in fishing around the tussock tufts, as well as elsewhere, and in that space of time I secured only four larvæ—two dead ones and two that were very much alive. Thus it appears that dead larvæ are not so easily secured as are live ones since larvæ were really abundant before the application.

About ten feet distant from the area treated with Phinotas oil larvæ were as numerous as previously, even though a thin coating of oil was present over the surface where it had spread from the treated part.

This Phinotas oil was described in the report for 1902, and it is a most powerful destroyer of larval life. Unfortunately it kills fish and other aquatic life as readily as it does wrigglers, and therefore is not suitable for general use; but in cases like this it would seem to be just the thing and, while we may not be able to kill off all the larvæ in a swamp, we can at least reach and destroy so large a proportion of them as to reduce the pest to harmless numbers.

Description of the Larva

Length 6—7.5 mm.=.24-.30 of an inch from head to end of ninth abdominal segment. It is a robust wriggler resembling in life the larva of *Culex jamaicensis*. In color it is white, tinged

with a clear transparent green which is often the predominating hue. The head is pale brown, much broader than long, rounded in front and flat at the sides; four large and four small tufts of hair arise from the vertex, two of the large ones of 6 or 7 hairs each from the central portion, between which the four small tufts are situated, and one of 10 or 11 hairs near the base of each antenna. Of the small tufts the anterior pair are each composed of 6 hairs, the posterior pair of 7 each. There is also another pair of moderate sized hair tufts near the base of the head just below and inward of the eyes; these are composed of five hairs each. The eyes are remarkably small, black and placed far down on the sides of the head. The antenna (fig. 18, 3 and 4) is very long and somewhat filamentous, infuscated at basal third and almost colorless beyond; a large tuft of 18 to 20 long hairs arises from an offset at the basal third and from this point the shaft is continued for some little distance, apparently as a thickened side of a hollow tube which is open on one side to the apex of the main shaft; this apex is terminated by two long needle-like spines and the filamentous process has at its end a very small articulated spine. The mentum (fig. 18, 5) is triangular in form with a deeply excavated base and six large teeth on each side of an apical one, besides a small tooth which is sometimes present near the base. The mandible (fig. 18, 6) presents much the appearance of that of the ordinary *Culex* (sens. lat.) type, but has three curved dorsal spines and the teeth are small and situated some distance back from the apex. The maxiliary palpus (fig. 18, 7) offers little that is peculiar, but the subapical spine is exceptionally long and blade-like and the basal process is rather small with curved apical teeth.

The thorax and abdomen are normal in form, the former with the usual number and location of long hair tufts; but the abdomen has only one tuft of two hairs on each side of the first segment, the following five each having but a single long lateral hair, while segments 7 and 8 have none except the several short hairs which are common to all segments. The eighth segment bears the lateral patches of scales, each of which is composed of from 12 to 16 scales arranged in an irregular, partly double row. The individual scale (fig. 18, 10) is lanceolate, with a long apical spine and

fringes of small spines at the sides. The ninth segment is somewhat variable in length but is always longer than broad and is completely encircled by a light brown chitinous ring. The ventral brush is normal but the dorsal hair tufts are four in number instead of the usual two. The anal gills are slightly longer than the width of the ninth segment and are supplied with obvious trachea. The breathing tube (fig. 18, 8 and 9) is a highly complex organ representing an extreme modification of the ordinary anal siphon. In color it is pale brown, with the extreme base and apical half strongly infuscated. From a dorsal aspect (fig 18, 9) it is bottle shape* with the basal half greatly dilated. From the side the apical half curves slightly dorsally and two long blade-like spines arise from large papillæ situated on a distinct dorsal offset. The constricted portion of the tube is provided within with projecting flaps which appear to hold the inner chitinous tube in position. The apex of each lateral set of flaps is furnished with six horizontally extended hooks. The inner tube, to which the trachea are attached at its base, is a complicated structure in itself, being composed of several distinct pieces One small elongate piece forms the ventral wall, while another much larger piece extends curvedly from one edge to the other. From the apex of the tube thus formed extend two small tubular structures terminated at their apices by an articulated, irregular, corneous piece which by the action of the long, somewhat chitinous piece coming from the interior of the eight abdominal segment is capable of being thrust forward and horizontally outward. Another separate little piece on the dorsal side of the main inner tube has a serrated edge which is plainly seen from a side view of the entire siphon.

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Culex sylvicola was taken only twice as a larva, once on May 4th in the Orange Mountains, a new locality for the species, and again on May 7th, in the Livingston Park woodland swamp. It proved to be much less common than in past years.

Culex abfitchii has continued to be a pest in certain wooded sec-

*The drawing was made from a balsam mount, and is consequently much broader and the outline distorted.

tions of the State. At Livingston Park they were present in limited numbers; at Short Hills, though abundant, they were not nearly so bad as in 1906; but in portions of the Great Piece Meadows, and in certain timber regions along the Pequest River in Warren county, they appeared in great swarms which made it almost impossible to stay in the woods.

Culex canadensis occurred quite generally throughout the wooded portions of the State; but was not exceptionally abundant anywhere, and of *C. sylvestris* the same may be said except that it breeds in the open rather than in the woods.

Culex abserratus of which a number of specimens were taken in New Jersey in both 1905 and 1906, appeared this season in comparatively large numbers and was found at Short Hills on the Orange Mountains, and in the Livingston Park woods. As previously recorded it is the first of the spring species to appear, and as a larva almost disappears before *canadensis* or *abfitchii* begins to hatch.

Culex aurifer breeds in much the same sort of swamps as *C. perturbans* and as adults the two are often found together. This fact previously led us to search for *perturbans* in *aurifer* breeding places; but without success because we were seeking a free swimming larva. In the same pool where *perturbans* was first supposed to breed, a large number of *aurifer* larvæ and pupæ were found on May 11th, 1907. A single larva was taken also at Short Hills, and as an adult it occurred in swarms at Swartswood Lake and Springdale, Sussex county, on July 10th, and in smaller number at Culver's Lake on the same day. This species, like *C. abfitchii,* remains on the wing for the greater part of the summer, although there is but a single spring brood.

Culex melanurus is recorded as occurring as a larva as late in spring as May 5th, and it was believed that there was no recurrence until September or October. In 1907, however, a number of large larvæ were taken at Lahaway on August 1st, and in the same pool was a full brood of very young larvæ which had apparently just hatched. A dozen single egg-shells and a cluster of five and another of twenty-seven were also fished from the pool, which indicates that the egg laying habits of this species are similar to the others of the *pipiens* group to which the adults belong.

It may be, then, that the species breeds continuously during the summer. The eggs are laid in agglutinated boat-shaped rafts which float upon the surface of the water, and the individual eggs in outline are the same as those of *C. pipiens;* but are slightly larger, darker in color and with the surface more coarsely papillose.

Marriage Flight of C. cantator. Until June 15th, *C. cantator* adults were seen in Highland Park, near New Brunswick, only in twos and threes, and in one case there were half a dozen; but on this date females were found all over the garden and porch and a dozen were dancing over the window panes in the hallway.. It was beginning to grow quite dusk when I discovered a swarm of about 200 male adults dancing in the air about 7 or 8 feet from the ground. This I watched until dark in the hopes of seeing without question the females carried away by the males. At intervals of every few minutes there would be a commotion in the swarm and sometimes (not always) something would leave the swarm in a straight line. Except once it did not appear, however, that there was more than one mosquito leaving the mass. In this case it was either a male and female *in copula,* or a single frail insect larger than a mosquito. The increasing dusk at the time of this incident was the cause of my not being positive. That there were many female mosquitoes near the swarm was evidenced by the fact that I was continually being bitten by them at the time, and I was lying directly beneath the swarm using the sky as a background.

Though the mating of the sexes was not positively witnessed, it is more than probable that this was the purpose of their congregation, and it is therefore interesting to note that the nearest place that these mosquitoes could have bred is on the Raritan meadow, about five miles distant in a direct line.

Query: Did the female mosquitoes return to their breeding grounds when fertilized, or did they die without ovipositing?

Little has been seen of the species of *Corethridæ* during the season of 1907. *Sayomyia albipes* was taken once from a woodland swamp at Westville on July 5th. *Corethra cinctipes* occurred rather commonly in all spring collections of woodland mosquitoes; but nothing that is new has been added to its life history.

One species of this genus new to the State, *Corethra lintneri,* was taken from woodland pools at Short Hills on April 30th, and adults hatched on May 15th and 16th. The larvæ were taken in some numbers in company with *canadensis, abfitchii* and *abserratus* and were supposed to be those of *C. cintipes* which they exactly resembled; being perhaps a little more pink in color and slightly smaller. Not until adults emerged was it discovered that it was a new species and then there were no larvæ left. The adult may be distinguished from *Corethra cinctipes,* the only other representative of the genus known to occur in the State, by its pale yellow color and darker thorax and by yellow, unbanded legs.

Detailed description of the Adult. Length 4.5–5mm.=.18–.20 of an inch. The head is pale yellowish to fuscous; both pairs of palpi and short proboscis fuscous; antennæ in female slender, setose, pale yellow, darker apically and with a ring of fuscous at the base of the joints; in the male plumose, the shaft ringed brown and yellow, the fine, long hairs brownish. Thorax yellowish-brown in the female, fuscous in the male and clothed rather scantily with long golden yellow hairs especially posteriorly; two nude lines slightly darker than the rest of the thorax begin at the anterior margin of the mesonotum and extend backward to a little beyond the middle. Pleura dirty white to slaty gray. Abdomen of female yellowish, irregularly marked with brownish, especially laterally; of male yellowish with brown basal bands which become broad and triangular in form at the sides, and tend to completely cover the apical segments; pale yellow hairs are evenly scattered over the surface in both sexes. Legs yellowish; a diffuse brown ring just before the apex of the femora; end joints of tarsi becoming brown apically; last joint wholly brown. Claws of male sickle-shaped with a long, simple, median tooth and a somewhat shorter, basal serrate tooth within the curve; the posterior claws have in addition a fine, long, spine-like branch outside the curve. The female claws are smaller, with a single, basal, serrated tooth, and are alike on all feet. The wings are hyaline, with the veins and margins clothed with long yellow, hair-like scales.

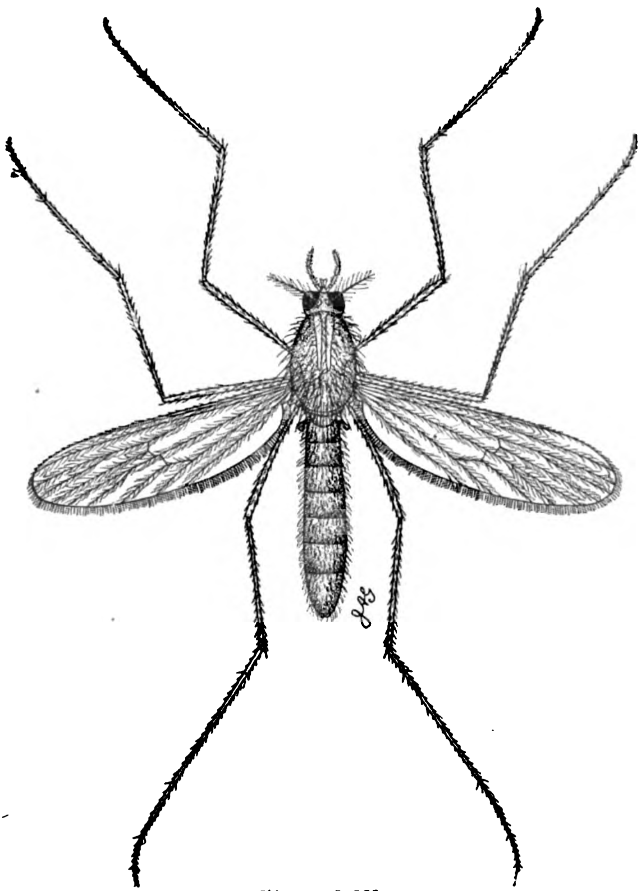

Figure XIX.

Corethra lintneri Felt; greatly enlarged. Original.